# FINAL SUBMITTAL

# ENERGY SURVEY OF

# EISENHOWER ARMY MEDICAL CENTER
# FORT GORDON

## AUGUSTA, GEORGIA

## VOLUME I

## NARRATIVE REPORT

CONTRACT NO. DACA01-94-D-0038

**PREPARED FOR:**

U.S. ARMY CORPS OF ENGINEERS
SAVANNAH DISTRICT

**PREPARED BY:**


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PROJECT NO. 6941331005

DECEMBER 23, 1996

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# 1.0 INTRODUCTION

## 1.1 AUTHORIZATION

The Energy Survey of the Eisenhower Army Medical Center (EAMC), Fort Gordon, Augusta, Georgia was authorized by the Department of the Army, Savannah District Corps of Engineers, under Contract Number DACA01-94-D-0038, Task Number 0005.

## 1.2 OBJECTIVES

The objectives of this contract, as explained in the Detailed Scope of Work (Tab A in Volume II) of the contract, are as follows:

- Perform a complete energy audit of the entire Eisenhower Army Medical Center's (EAMC) heating and cooling systems, lighting system and other systems and areas.
- Perform a comprehensive analysis of all data collected during the audit.
- Identify all Energy Conservation Opportunities (ECOs) including low cost/no cost ECOs and perform complete evaluations of each. Energy equipment replacement projects already underway, approved, or planned by the Medical Center staff will be factored into the evaluations.
- Prepare programming documentation for all Federal Energy Management Program (FEMP) and/or Energy Conservation Improvement Program (ECIP) projects.
- Prepare implementation documentation and instructions for those projects recommended for accomplishment by local forces.
- List and prioritize all recommended ECOs.
- Prepare a comprehensive report which will document the work accomplished, the results of the field investigation and engineering analysis, the conclusions and recommendations.

## 1.3 PHASES OF WORK

The work to be performed under the contract has been divided into three phases:

- Phase I--Field Investigation and Data Gathering.
- Phase II--Data Analysis. Analysis of data, identification of potential projects, performance of feasibility and economic studies and preparation of Life Cycle Cost Analysis forms. During this phase, all potential projects which produce energy and/or dollar savings will be identified and evaluated as to their technical and economical feasibility. Projects will be ranked according to their savings-to-investment ratio (SIR) value.
- Phase III--Report Preparation. Complete documentation of work accomplished. Project documentation for all justifiable ECOs.

There are three submittals planned for this project - Interim, Prefinal and Final.

## 1.4 WORK ACCOMPLISHED

An entrance meeting was held with the Director of the Department of Public Works (DPW), the Fort Gordon Energy Manager and other engineering personnel to discuss the scope of work, current energy initiatives at Fort Gordon and work plans and schedules for the field survey.

The initial field survey of the EAMC was performed on October 23 through 27, 1995. During that time, a team of engineers from Reynolds, Smith and Hills, Inc. (RS&H) performed tests, made observations and conducted interviews with installation personnel. The exit meeting was held at the end of the week with the Director of DPW, the Fort Gordon Energy Manager, and other engineering and maintenance personnel. Additional field surveys were conducted on November 15 through 17, 1995 and January 22 through 25, 1996.

Since that time, work has been performed in the analysis and documentation phases of the project. This included ECO evaluation, Life Cycle Cost Analysis, and documentation of the results and site survey observations. The results of these efforts formed the Interim Submittal.

Comments were received for the Interim Submittal and discussed during a review meeting at Fort Gordon on May 24, 1996. An additional site visit was made on June 18 through 20, 1996 to collect additional information for this study. Responses to the comments and additional analysis were incorporated into the Prefinal Submittal.

A site visit was made during the week of August 12, 1996 to gather additional data on the hospital steam pressure regulating valve and boiler condensate return system. Comments were received for the Prefinal Submittal and discussed during a review meeting at Fort Gordon on November 21, 1996. Responses to the comments and additional O&M recommendations were incorporated into the Final Report.

## 1.5 WORK PLAN

The plan for the remaining effort is shown in Figure 1.5-1. The plan includes schedules, durations of tasks and dates.

## 1.6 REPORT ORGANIZATION

The report consists of five volumes. Volume I, the Narrative Report, contains the results of all the field investigations, analysis and project development. The Detailed Scope of Work, Meeting Minutes and all backup data and calculations are found in Volume II, the Appendices. The field investigation notes are in Volume III and project documentation forms necessary for receiving funding are in Volume IV. Also included is an Executive Summary volume.

12-03-96

**FORT GORDON**

**Eisenhower AMC Energy Audit**



| NAME | START | END | STAT |
|---|---|---|---|
| + Ft. Gordon Med Center | 09-25-95 | 12-24-96 | P |
| + Interim Submittal | 09-25-95 | 11-22-96 | P |
| - NTP | 09-25-95 | 09-25-95 | P |
| + ACTUALS | 09-25-95 | 11-22-96 | P |
| - Pres. to 11/10 | 09-25-95 | 11-10-95 | P |
| - 11/13 to 01/05 | 11-13-95 | 01-05-96 | P |
| - 01/08 to 01/26 | 01-08-96 | 01-26-96 | P |
| - 01/29 to 02/23 | 01-29-96 | 02-23-96 | P |
| - 02/26 to 05/24 | 02-26-96 | 05-24-96 | P |
| - 05/25 to 06/28 | 05-27-96 | 06-28-96 | P |
| - 06/29 to 07/26 | 07-01-96 | 07-26-96 | P |
| - 07/27 to 08/23 | 07-29-96 | 08-23-96 | P |
| - 08/24 to 09/27 | 08-26-96 | 09-27-96 | P |
| - 09/28 to 10/25 | 09-30-96 | 10-25-96 | P |
| - 10/26 to 11/22 | 10-28-96 | 11-22-96 | P |
| + Remaining Work | 11-22-96 | 12-24-96 | P |
| - Prefinal Review | 11-22-96 | 11-22-96 | P |
| + Final Submittal | 11-25-96 | 12-24-96 | P |
| - Incorp. Comm/Anal. | 11-25-96 | 12-10-96 | P |
| - Documentation | 12-11-96 | 12-24-96 | P |
| - Submittal | 12-24-96 | 12-24-96 | P |

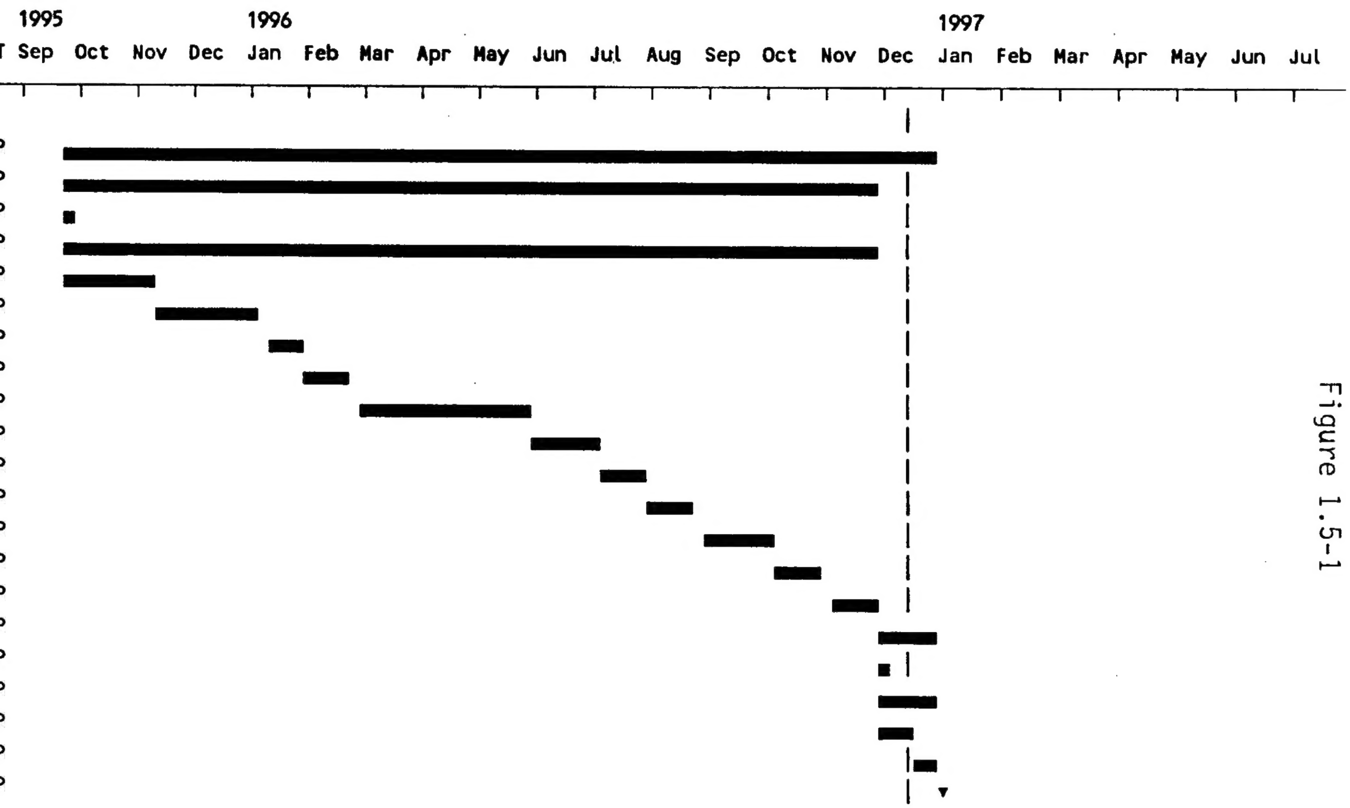



Figure 1.5-1

C: Completed P: Planned a : Actual Flag ▼ : Milestone ▬ : Critical ▪▪▪ : Normal Scale: 1 Month = 5 character(s)

▸▸▸ : Resource Delay ... : Slack »»» : Actual Progress



FINAL

Volume I is the Narrative Report and its organization is explained here. Following a brief introduction in Section 1.0, the existing conditions at the Eisenhower Army Medical Center are discussed in Section 2.0. This includes a discussion of the FY96 Major Renovation Project, a description of the facility and current and past energy use patterns. Section 3.0 describes the techniques used to perform this study. Section 4.0 contains the results of the analysis of the energy conserving opportunities. The ECO Implementation Plan and the effects on energy use at Fort Gordon are located in Section 5.0.

# 2.0 EXISTING CONDITIONS

## 2.1 FY96 MAJOR RENOVATION PROJECT

A major renovation project for the EAMC was funded for FY96. This project includes major modifications to the heating and cooling plant as well as the HVAC system in the hospital. The following is a list of construction tasks from the Project Documents for the funded modifications to the Eisenhower Army Medical Center and its central heating and cooling plant. All ECOs will be evaluated on the basis that all of these renovations will be implemented.

Between the Interim and Prefinal Submittals, the renovation project was expanded to include replacement of all three boilers and associated controls. Therefore, some boiler improvement ECOs were evaluated but are not recommended.

### Boiler Plant

Replace:
- Four feed water pumps
- Two condensate transfer pumps
- Water softener system
- Condensate return unit
- Three boilers and associated controls
- Steam and condensate piping and equipment insulation
- Inlet vortex dampers on forced draft fans

Remove:
- Economizers and induced draft fans

### Chiller Replacement

Replace:
- Two centrifugal chillers (Nos. 1 and 3) Refrigerant R-22
- Three primary chilled water pumps P-1, P-2 and P-3
- Three secondary chilled water pumps and add variable speed drives (VSDs) on pump motors
- Three cooling towers and add VSDs to all cooling tower fan motors
- Three condenser water pumps
- Condenser water piping (the two centrifugal chiller towers will be manifolded)
- All insulation

The chillers specified show a rated efficiency of 0.64 kW/ton and an APLV = 0.608 kW/ton. This is about the same efficiency as the existing units which have a rated efficiency of 0.65 kW/ton. Each of the new chillers have a nominal capacity of 1,080 tons, compared to 1,050 tons for the existing machines. This increases the plant cooling capacity by 60 tons.

### Plant Management System

Replace:
- All pneumatic operators
- Outside air dampers (or repair)
- Pneumatic controls system with direct digital type
- Three-way chilled water valves with two-way types
- Cooling coil and condensate drain pans

Cooling coil header piping insulation (inside fan room)
Reheat coils

Install: Chilled water line bypass to create primary/secondary supply loops. VSD on SF #5 and SF #6 supply and return fans to maintain positive pressure in controlled zone with respect to adjacent areas.

New Energy (Plant) Management Control System

Features Include:

SF-1, SF-2 and SF-3

Scheduled start/stop, optimum start/stop and economizer Cold deck temperature reset
Hot deck temperature reset
Operation Schedule
SF-1 0600 - 1700
SF-2 0600 - 2100
SF-3 Continuous

OR AHU

Scheduled start/stop, optimal start/stop, day/night setback, economizer
Operation Schedule: 0700 - 1800

SF-4A and SF-4B

Scheduled start/stop, optimal start/stop, and economizer
Operation Schedule - Continuous

ICU AHU

Scheduled start/stop, optimal start/stop, day/night setback
Operation Schedule - Continuous

Kitchen Exhaust Fan

Scheduled start/stop
Operation Schedule - 0400 - 1900
Interlocked with make-up AHU

Hot Water Pumps

Scheduled start/stop, optimal start/stop
Day/night setback
Operation Schedule - Continuous

Chillers

Schedule start/stop, optimum start/stop
Chilled Water Reset, Condenser Water Reset
Chiller Demand Limit, Chiller Selection
Day/night setback (secondary CWP control)
Operation Schedule - Continuous

The absorption chiller and auxiliaries are used for demand limiting and during emergency power use.

Condenser water maintained at OSA wet bulb +5 degrees F, low limit 60 degrees F.

SF-7 (2nd Floor Mechanical Room Ventilation)

Scheduled start/stop, optimum start/stop, demand limiting, day/night setback, economizer
Operation Schedule - Continuous

Exhaust Fans 1 Through 17

Scheduled start/stop
Operation schedule:

| | |
|---|---|
| EF-1:6 and EF-8:14 - | Continuous |
| EF-7 (Kitchen Hoods) | 0400 - 1900 |
| EF-15:17 (Sterilization, Kitchen, Allergy Clinic) | 0500 - 1900 |

## 2.2 SYSTEMS DESCRIPTION

**Building**

The Eisenhower Army Medical Center (EAMC), Building 301, is located in the northeastern portion of Fort Gordon just off Chamberlain Avenue. It is easily accessed through McKenna Gate near U.S. Highway 78 and Gordon Highway (see Figure 2.2-1). The EAMC was brought into operation in 1976. The facility has 13 floors with 630,849 square feet of floor space. It is rectangular-shaped with the main entrance on one of the longer sides facing almost due north.

There are entrances to the hospital from all four sides. The main entrance and emergency room entrances are on the second level on the north side. The east side entrances are also on the second level and access the Magnetic Resonance Imaging (MRI) and Family Practice wings. The south entrance is on the fourth floor to the primary military administration areas. The loading docks are located on the west side and provide entrance to the third floor.

The exterior is approximately 15 percent windows. The windows are primarily single pane, but virtually all have blinds and/or drapes. The windows are recessed almost two feet to provide some shading.

The building peak population is estimated at 2,000 during the day. During the two other shifts, the number of people drops to about 400.

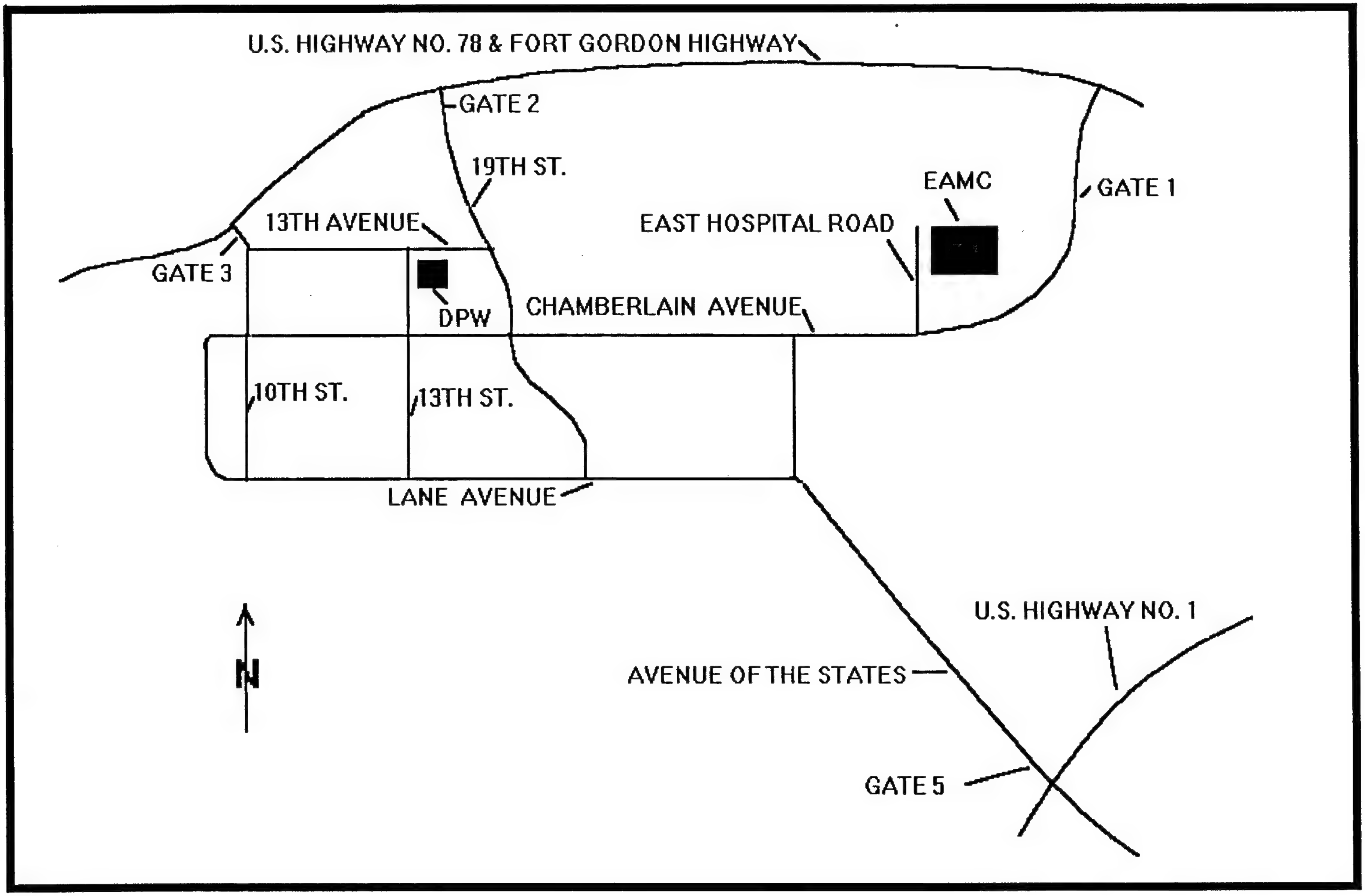



Figure 2.2-1 Building Area Diagram

Facility operation hours are 7:30 am to 4:30 pm for the first four floors. The fifth through thirteenth floors are operational 24 hours per day. The exceptions are shown in the table below:

| Floor | |
|---|---|
| 1 | Labs - 24 hours/day |
| 2 | Information Desk, Radiology, Emergency - 24 hours/day |
| 3 | Intensive Care, Pharmacy, CMS (Sterilization) - 24 hours/day, Surgical Suite is available for emergencies at any time |

The Heating and Cooling Plant is located immediately west of the hospital. Maintenance for the hospital as well as the Heating and Cooling Plant is contracted to Johnson Controls Company.

## Lighting Systems

The lighting system types were inventoried and are contained in Table 2.2-1. The predominate lighting fixture is a two foot by four foot (two-by-four) recessed troffer with acrylic lens. The fixtures use two F40 CW (cool white) lamps with a single ballast and are used for supply and return of conditioned air. The original ballast is a standard magnetic type. Maintenance personnel estimate that about one half have been replaced with energy efficient magnetic types. Many office areas use two-by-four, four-lamp fixtures to provide higher lighting levels. Mercury vapor lamps are used in high ceiling areas such as lobbies and the cafeteria dining room. Lab areas on the first floor use four by four, eight lamp fluorescent fixtures to provide even higher lighting levels.

New T8 lamp fixtures with electronic ballasts are being installed in renovated areas. The tenth floor and the clinics in the northwest corner of the first floor have new parabolic fixtures using this high efficiency lighting system.

The Family Practice wing has a slightly different system. The primary fixtures are two-by-two U-bend and two-by-four parabolics using two, 34-watt fluorescents and energy efficient magnetic ballasts. The MRI wing has similar fixtures but uses F40 CW lamps with energy efficient magnetic ballasts.

Incandescents are used in smaller quantities throughout the hospital, primarily in restrooms and in some high ceiling areas.

Lighting levels were measured throughout the hospital. The results and a comparison with design requirements by area type are listed in Table 2.2-2. The only areas that are consistently over lighted are

Table 2.2-1 Lighting Systems Inventory

| Floor | Space | Description | Area (sf) | Fluorescents 2L f40U | 2L f40wm | 2L f40 | 3L f40wm | 4L f40wm | 4L f40 | 2L f32 | 6L f40 | 8L f40 | 2L f96 | circln | Incandescents 1L(N) a60 | 1L(R) a100 | 1L p150 | 1L a200 | M-V (L) 175w |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1a | Clinics | 6,048 | | | 31 | | | | | | | | | | 14 | | | |
| 1 | 1b | " | 8,064 | | | 164 | | | 1 | | | | | | | | | | |
| 1 | 1c | Admin/Comp. | 10,080 | | | 111 | | | 28 | | | | | 66 | | 47 | | | |
| 1 | 1d | Surg. Clinic | 10,080 | | | 81 | | | 83 | | 8 | | | | | 11 | | | |
| 1 | 1e | Admin/Comp. | 5,040 | | | 76 | | | | | | | | | | 2 | | | |
| 1 | 1f | Admin. | 4,200 | | | 64 | | | | | | | | | | 4 | | | |
| 1 | 1g | " | 2,856 | | | 30 | | | 6 | | | | | | | 4 | | | |
| 1 | 1h | Labs | 5,040 | | | 40 | | | | | | 23 | | | | | | | |
| 1 | 1i | Phys. Med. | 10,080 | | | 103 | | | 37 | | | | | | | 6 | | | |
| 1 | 1j | " | 8,064 | | | 111 | | | 5 | | | | | | | 20 | | | |
| 1 | 1k | Labs | 6,116 | | | 89 | | | 31 | | | | | | | 4 | | | |
| 1 | 1l | " | 9,912 | | | 52 | | | | | | 93 | | | | | | | |
| 2 | 2a | Mech. Rm. | 6,720 | | | 23 | | | | | | | | | | 8 | | | |
| 2 | 2b | Clinics | 7,392 | | | 62 | | | 53 | | | | | | | | | | |
| 2 | 2c | Lobby/Admin | 10,080 | | | 66 | | | | | | | | | | | | | 113 |
| 2 | 2d | Emergency | 10,080 | | | 93 | | | 68 | | | | | | | 4 | | | |
| 2 | 2e | Clinics | 6,048 | | | 50 | | | 38 | | | | | | | 5 | | | |
| 2 | 2f | " | 7,256 | | | 70 | | | 54 | | | | | | | 5 | | | |
| 2 | 2g | " | 5,292 | | | 64 | | | | | | | | | | 9 | | | |
| 2 | 2h | Adm/Records | 8,064 | | | 138 | | | 13 | | | | | | | 2 | | | |
| 2 | 2i | Clinics | 7,812 | | | 78 | | | | | | | | | | 2 | | | |
| 2 | 2j | " | 3,024 | | | 27 | | | 14 | | | | | | | | | | |
| 2 | 2k | " | 4,645 | | | 56 | | | | | | | | | | 10 | | | |
| 2 | 2l | " | 4,990 | | | 31 | | | 19 | | | | | | | 5 | | | |
| 2 | 2m | Admin. | 3,744 | | | 63 | | | | | | | | | | 1 | | | |
| 2 | 2n | Clinic | 3,216 | | | 40 | | | | | | | | | | 1 | | | |
| 2 | 2o | " | 10,080 | 2 | | 61 | | | 70 | | | | | | | | | | |
| 2 | 2p | " | 8,064 | 16 | | 44 | | | 70 | | | | | | | 20 | | 9 | |
| 2 | 2q | " | 8,064 | | | 100 | | | 11 | | | | | | | | 4 | | |
| 2 | 2r | " | 8,064 | | | 139 | | | 23 | | | | | | 3 | | 6 | | |
| 2 | - | MRI | 2,940 | | | | | | 30 | | | | | | | | | | |
| 2 | - | Fam. Pract. | 26,000 | 45 | 134 | | 11 | 152 | | | | | | | | | | | |
| 3 | 3a | Mech. Rm. | 4,032 | | | 17 | | | | | | | | | | 8 | | 1 | |
| 3 | 3b | Cafeteria | 10,512 | | | 17 | | | | | | | 84 | | | 10 | | | |
| 3 | 3c | Dining Rm | 9,744 | | | 52 | | | | | | | | | | 4 | | | 54 |
| 3 | 3d | Admin | 10,206 | | | 110 | | | 44 | | | | | | | 37 | 2 | 6 | |
| 3 | 3e | Linen | 7,776 | | | 92 | | | | | | | | | | | 3 | | |
| 3 | 3f | Admin | 10,344 | | | 116 | | | 9 | | | | | | | | | | |
| 3 | 3g | Pharm. Stg. | 4,656 | | | 57 | | | 15 | | | | | | | | | | |
| 3 | 3h | Surgical | 4,536 | | | 55 | | | | | | | | | | 27 | | | |
| 3 | 3i | Admin | 4,032 | | | 49 | | | 12 | | | | | | | 6 | | | |
| 3 | 3j | " | 5,040 | | | 32 | | | 36 | | | | | | | | 4 | | |
| 3 | 3k | Pharm. Stg. | 10,080 | 3 | | 107 | | | 8 | | 2 | | | | | 16 | | | |
| 3 | 3l | Surgical | 4,536 | 21 | | 49 | | | 6 | | | | | | | 3 | | 1 | |
| 3 | 3m | Supply | 10,080 | | | | | | 8 | | | | | | | | | | 76 |
| 3 | 3n | " | 10,080 | | | | | | 17 | | | | | | | | | | 72 |
| 3 | 3o | " | 6,048 | | | 20 | | | | | | | | | | | | | 26 |
| 3 | 3p | Surgical | 8,064 | | | 120 | | | 11 | | | | | | | 5 | 8 | | |
| 4 | floor | ^ | 22,200 | | | 98 | | | 87 | | | 3 | 10 | | | 19 | | 24 | 151 |
| 5 | floor | \| | 23,100 | | | 95 | | | 26 | | | | | | 52 | 23 | | | |
| 6 | floor | \| | 27,000 | 4 | | 267 | | | 16 | | | | | | 57 | 41 | | | |
| 7 | floor | Admin | 27,000 | 4 | | 267 | | | 16 | | | | | | 57 | 41 | | | |
| 8 | floor | + | 27,000 | 2 | | 267 | | | 16 | | | | | | 57 | 41 | | | |
| 9 | floor | Patient | 27,000 | 2 | | 267 | | | 16 | | | | | | 57 | 41 | | | |
| 10 | floor | Areas | 27,000 | 2 | | 102 | | | 16 | 148 | | | | | 54 | 41 | | | |
| 11 | floor | \| | 27,000 | 2 | | 267 | | | 16 | | | | | | 57 | 41 | | | |
| 12 | floor | \| | 27,000 | 2 | | 260 | | | 11 | | | | | | 54 | 41 | | | |
| 13 | floor | v | 27,000 | 5 | | 243 | | | | | | | | | 78 | 39 | | | |
| 14 | floor | Mech. Rm. | 11,250 | | | 48 | | | | | | | | | | | | | |
| Totals | | | 629,471 | 110 | 134 | 5231 | 11 | 152 | 1040 | 148 | 10 | 119 | 94 | 66 | 526 | 668 | 27 | 41 | 492 |
| 1st Floor | | | 85,580 | 0 | 0 | 952 | 0 | 0 | 191 | 0 | 8 | 116 | 0 | 66 | 0 | 112 | 0 | 0 | 0 |
| 2nd Floor | | | 122,635 | 18 | 0 | 1,205 | 0 | 0 | 433 | 0 | 0 | 0 | 0 | 0 | 3 | 72 | 10 | 9 | 113 |
| MRI | | | 2,940 | 0 | 0 | 0 | 0 | 0 | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Fam. Pract. | | | 26,000 | 45 | 134 | 0 | 11 | 152 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3rd Floor | | | 119,766 | 24 | 0 | 893 | 0 | 0 | 166 | 0 | 2 | 0 | 84 | 0 | 0 | 116 | 17 | 8 | 228 |

hallways, but not excessively. On several floors, every other hallway fixture was de-energized which brought light levels near the minimum.

Two other areas are over lighted. These are the library on the fourth floor and the general office area in the family practice wing. Both areas use four-lamp two-by-four fluorescent fixtures which produce 103 foot candles in the family practice area and 150+ foot candles in the library. The Family Practice area is dual switched, allowing half of the fluorescents to be de-energized at the wall switch.

**Table 2.2-2. Light Levels (Foot candles)**

| AREA TYPES | REQUIREMENTS(1) | MEASURED |
|---|---|---|
| Clinics, exam rooms | 50 | 50-103(2) |
| Administrative | 50 | 50-95(2) |
| Patient Bedrooms | 30 | 10-50 |
| Library | 50 | 150+(3) |
| Toilets | 20 | 5 |
| Hallways | 10-15 | 10-35(4) |
| Computer | 50 | 70 |
| Kitchen | 70 | 50 |

**Notes:**

(1) Source: MIL-HDBK-1191, Department of Defense, Dental and Medical Treatment Facilities Design and Construction Criteria, October 1991.
(2) High values are in Family Practice wing, medical records area and exam rooms.
(3) Fourth floor library.
(4) On some floors half of the hallway lights have been de-energized. The light levels on these floors average ten foot candles.

## Heating And Cooling Systems

**Chilled Water System**. Chilled water production is accomplished by three chillers located in the south end of the central energy plant, Building Number 310. This facility also houses the boilers and is located across the street just west of the hospital. The chillers are numbered CH-1, CH-2 and CH-3 from west to east. These chillers provide chilled water (CHW) to provide space cooling in the hospital and the medical barracks that are

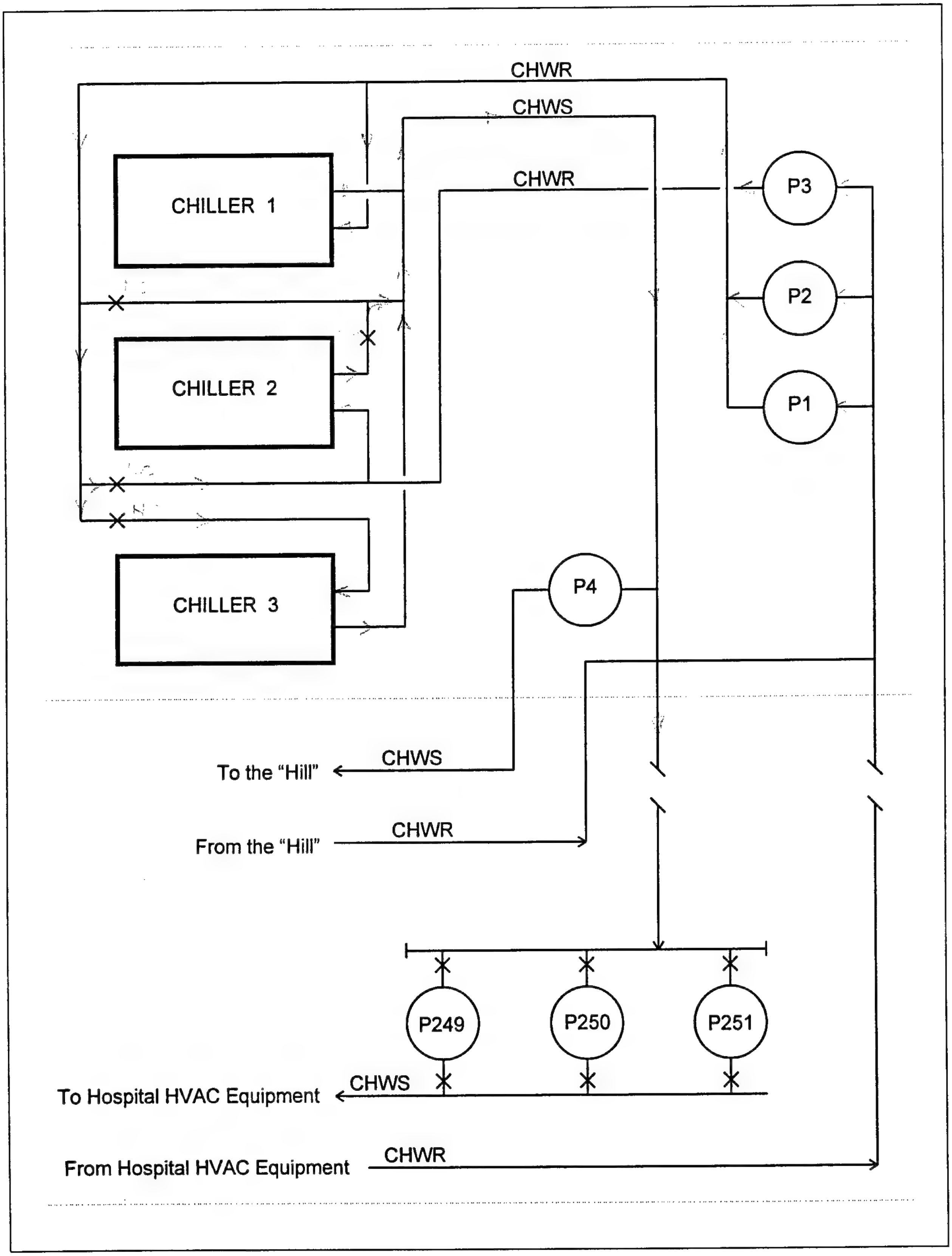
located south of the central energy plant. The chilled water supply is a single loop system with primary pumps located in the plant and booster pumps in series located in the hospital (see Figure 2.2-2).

**Chillers**. Chillers CH-1 and CH-3 are 1,050 ton, electrical-driven, centrifugal types manufactured by York. Originally designed in 1985, these chillers are rated at 0.65 kW/ton. These chillers are approximately ten years old and are in good condition. There have been several problems with chiller CH-1. The compressor has failed at least two times and been repaired by the manufacturer. In 1995, the rear bearings for the compressor motor failed. The motor was removed and sent to the manufacturer for rebuilding. The chilled water supply set point for the centrifugal chillers is 41.5 degrees F. The operator indicated chillers CH-1 and CH-3 provide a total of approximately 1800 tons of cooling during periods of peak cooling demand. Both centrifugal chillers are scheduled to be replaced in the FY96 Renovation Project.

The field investigation of these centrifugal chillers was accomplished during a sunny morning on October 26, 1995, while the outside air temperature was about 77 degrees F drybulb. Chiller CH-3 was operating at approximately 95 percent of full load amps and was the only chiller operating during the survey. The measured CHW supply and return temperatures were 44 degrees F and 54 degrees F, respectively. Chilled water flow was not calculated due to the extremely low differential pressure readings across the evaporator coils indicating extremely low flow. The chiller logs indicate the pressure difference has been between zero psig and five psig for over one year. The gauges were checked during the site visit and found to be properly calibrated.

Chiller CH-2 is a 500 ton, natural gas-fired absorption unit manufactured by Trane. The design COP is 1.07. This chiller was installed in early 1995. The field investigation of the absorption chiller was accomplished during a cool afternoon on November 16, 1995, while the outside air temperature was 58 degrees F. Chiller CH-2 was operating at approximately 60 percent of full load fuel input and was the only chiller operating during the survey. The measured CHW supply and return temperatures were 52 degrees F and 60 degrees F, respectively. The calculated chilled water flow was 1,987 gallons per minute (gpm), compared to the design value of 1,152 gpm. The calculated condenser water flow was 2,212 gpm, compared to the design value of 2,187 gpm. The condenser water flow is normal, but the chilled water flow exceeds the recommended maximum of 1,466 gpm. This could cause premature fouling in the evaporator tubes.

The loading of the absorption chiller was dictated by the leaving condenser water temperature and not the actual cooling load required by the hospital. The fuel input was manually adjusted to keep the leaving condenser water temperature at approximately 100 degrees F. Chiller CH-2 has not been operated very often due to excessive condenser water temperatures. This problem is discussed in detail in the paragraphs below on cooling towers.



CHWR
CHWS
CHWR
CHILLER 1
CHILLER 2
CHILLER 3
P3
P2
P1
P4
CHWS
To the "Hill"
CHWR
From the "Hill"
P249
P250
P251
CHWS
To Hospital HVAC Equipment
CHWR
From Hospital HVAC Equipment


**Figure 2.2-2**

The chilled water supply and return piping is manifolded for all three chillers. Three pumps (#1, #2 and #3) supply CHW to the hospital and an additional pump (#4) supplies CHW to the medical barracks. These pumps are located on the lower level of the central plant. Pump #1 is used during cold and mild weather and Pumps #1 and #2 operate during hot weather serving the centrifugal chillers. Pumps #1 and #2 each have a 100-horsepower motor. Pump #3 has a 30-horsepower motor and provides CHW supply and return for the absorption chiller. Pump #4 has a 20-horsepower motor and operates when cooling is required in the barracks.

There are three additional chilled water "booster" pumps located in a mechanical/electrical room on the first floor of the hospital. The "booster" pumps are all rated at 2,100 gpm and have 50 horsepower motors. These pumps are used to distribute CHW to the individual air-handling units and fan-coil units within the hospital. Two of these pumps were operating during the field investigation.

**Cooling Towers**. There are four cooling towers located just west of the central energy plant, one for each of the three chillers and one serving the emergency generator. The towers are numbered #1, #2 and #3 from east to west and serve the chillers with the same corresponding numbers. The tower serving the emergency generator is CT-4. All towers are cross-flow types with induced draft fans and open-basin water distribution systems. All distribution basins contained pipe scale which were partially clogging the drain holes. All make-up water valves were either missing or malfunctioning. Large amounts of water flow continuously to the tower basins irrespective of need. During much of the survey, the ground around the towers was under several inches of water due to tower basin overflow. The fans cycle to maintain approximately 80 degrees F condenser water to the chillers.

CT-1 has two cells and is generally in poor condition. The fill and drift eliminators are made of wood slats. Many are broken or missing and are covered with algae. During periods of operation, the area around the tower was saturated from drift.

CT-2, a single cell tower, was rebuilt in early 1995 to accommodate the new 500-ton absorption chiller. Outward appearances indicate that the tower is in good condition. The fill and exterior housing is new. However, during tests of the absorption chiller, we observed that much of the condenser water is bypassing the fill around the outside of the tower. During the absorption chiller test on November 16, 1995 we observed the condenser water supply at 95 degrees F and the return at 85 degrees F while the ambient conditions were 58 degrees F drybulb and 47 degrees F wetbulb. With these outdoor conditions, the tower should be able to provide about 57 degrees F return condenser water. We found that the condenser water flow around the fill is so great that when it mixes with the water coming through the fill (which measured 58 degrees F), it raises the basin water temperature to 85 degrees F. This greatly decreases the useful capacity of the absorption

chiller. We speculate that the fill has become blocked by condenser pipe scale. However, it is impossible to be certain without dismantling the tower housing.

CT-3 has two cells and is in fair condition. The fill is a plastic honeycomb type. Several sections of the fill are crushed or missing. The condenser pump, located adjacent to the tower, is leaking severely and frequently floods the areas around the towers.

CT-4 is a small single cell tower and is generally in poor condition. The fill is damaged in many places.

Towers CT-1, CT-2 and CT-3 along with their associated pumps and piping are scheduled to be replaced in the FY96 Renovation Project. Cooling tower fan motors will be equipped with variable speed drives (VSDs) which will be used to control condenser water supply temperatures to the ambient wet bulb temperature plus five degrees F.

<u>Air Handling Units (AHUs)</u>

**AHU-1, AHU-2 and AHU-3**

All three of these AHUs are contained within one large field erected housing located in Mechanical Equipment Room Number 2A-1 on the second floor. AHU-1, AHU-2 and AHU-3 serve the hospital's first floor (excluding Family Practice), second floor and third floor (excluding the surgical suite), respectively. The overall unit is constant volume with terminal reheat and has outside air dampers, return air dampers, relief air dampers, dry bulb economizer cycle controls, steam preheat coils with two-way control valves, roll filters, bag filters, chilled water cooling coils with three-way control valves, three supply air fans, two return air fans and four return air booster fans. All cooling coils, condensate drains, chilled water supply pipe in the mechanical room and pneumatic actuators are scheduled for replacement in the FY96 Renovation Project. The dampers for outside return and relief air are to be repaired or replaced. The pneumatic control system will be replaced with a direct digital control (DDC) type. Three-way chilled water valves will be replaced with two-way types.

All three AHUs utilize the same outside air intake, filters and cooling coils. There is a separate supply fan (SF-1, SF-2 and SF-3) for each floor served. The supply fans are all double-wide, double-inlet, v-belt driven centrifugal blowers with 100-horsepower motors.

The return air from each of the three floors is combined into a common return duct, and there are two-60 inch diameter, v-belt driven, vane axial return air fans (RA-1A and RA-1B) with 30-horsepower motors. These fans are located in the Mechanical Equipment Room Number 3A-1 on the third floor. The variable inlet vane dampers for RA-1A are in the "minimum" position and the dampers for RA-1B are approximately 25 percent

open. There are also four round axial flow "booster" fans mounted in the return air plenum just below the return air dampers. These were not operating during the survey.

The existing condition of these units is considered fair to good. Problems noted during the field investigation include dirty roll filters, a few small areas of bent fins on the cooling coils and the relays or actuators on the return air dampers are not working properly with the economizer cycle. Also, the chilled water lines in the AHU located directly downstream of the chilled water coils are very dirty and covered with some kind of growth.

**AHU-4E and AHU-4W**

AHU-4E and AHU-4W are large field erected AHUs located in Mechanical Equipment Rooms C-1 (east) and A-1 (west), respectively, on the 14th floor penthouse. These units are constant volume with terminal reheat for space temperature control. AHU-4E serves the east side of floors four through thirteen. AHU-4W serves the west side of the fourth floor, the northwest side of the sixth floor and the west side of floors seven through thirteen. Each one of these units is constant volume and has outside air dampers, return air dampers, relief air dampers, dry bulb economizer cycle controls, steam preheat coils with two-way control valves, roll filters, bag filters, chilled water cooling coils with three-way control valves, one supply air fan, one return air fan and one exhaust air fan.

The supply fans (SF-4A and SF-4B) are double-wide, double-inlet, v-belt driven centrifugal blowers with 125-horsepower motors and are located in AHUs 4E and 4W, respectively.

The return air fans (RA-2A and RA-2B) are 60-inch diameter, v-belt driven, vane axial fans with 30-horsepower motors. The fans return air to AHUs 4E and 4W, respectively. The variable inlet vane dampers for both RA-2A and RA-2B are in the "maximum" open position.

The existing condition of these units is considered fair to good. Problems noted during the field investigation include:

- SF-4A: A few small areas of bent fins on the cooling coils. One blade is missing from the outside air dampers and one blade is missing from the internal relief air dampers. The controls are calling for economizer operation when the outside air temperature drops below 50 degrees F but there is a problem within the controls cabinet that is not allowing the economizer cycle to work properly.
- SF-4B: A few small areas of bent fins on the cooling coils. One of the actuators on the external relief air dampers is coming loose from the wall so the dampers will not fully open. The outside air intake dampers will not fully open and the controls are not calling for

economizer operation until the outside air temperature drops below 20 degrees F. These problems are not allowing the economizer cycle to work properly.

**AHU-5**

AHU-5 is a field-erected AHU located in Mechanical Equipment Room Number 5B-22 on the fifth floor. This is a constant volume multizone unit (13 zones) that serves the intensive care unit areas of the fifth floor and the western third of the sixth floor, which was originally the newborn nursery and delivery suite. This unit is constant volume and utilizes 100 percent outside air, steam preheat coils with two-way control valves, roll filters, bag filters, chilled water cooling coils with three-way control valves, a supply air fan, steam humidifiers, hot water reheat coils, 97 percent final filters and an exhaust fan.

The supply air fan (SF-5) is a single-wide, single-inlet, v-belt driven centrifugal blower with a 20-horsepower motor. The exhaust fan (EF-5) is a vane axial type with v-belt drive and inlet vane dampers.

In the major Renovation Project for FY96, the SF-5 motor will be supplied with a VSD to allow it to maintain positive pressure with respect to adjacent areas.

Existing condition of this unit is considered fair.

**AHU-6**

AHU-6 is a field erected AHU located in Mechanical Equipment Room Number 3O-2 on the third floor. This is a constant volume multizone unit (12 zones) that serves the surgical suite area of the third floor. This unit is constant volume and utilizes 100 percent outside air, steam preheat coils with two-way control valves, roll filters, bag filters, chilled water cooling coils with three-way control valves, a supply air fan, steam humidifiers, hot water reheat coils, 97 percent final filters and an exhaust fan.

The supply air fan (SF-6) is a double-wide, double-inlet, v-belt driven centrifugal blower with a 40-horsepower motor. The exhaust fan (EF-6) is a vane axial type with v-belt drive, inlet vane dampers and a five-horsepower motor.

Existing condition of this unit is considered fair. The humidity controls are set for 40 percent relative humidity. Planned renovations to this AHU include new fan motor, rebuilt fan, new variable frequency drive, new cooling coils, new preheat coils and new direct digital controls.

**Kitchen Make Up Air Handling Unit**

The kitchen make-up air unit (MAU) is a field erected AHU located in Mechanical Equipment Room Number 3A-1 on the third floor. The MAU is a single zone, constant volume, heating only unit that provides make-up (supply) air to the range hoods and other areas of the kitchen. This unit utilizes 100 percent outside air, a steam heating coil with two-way control valves, roll filters, bag filters, and manual inlet guide vanes. The supply fan is a single wide, single-inlet centrifugal fan with v-belt drive and a 20-horsepower motor.

This unit is in fair condition. The roll filters were dirty. The heating coil was slightly dirty, and there were some fins missing where leaks had been repaired.

A combination exhaust and grease collection system is used to remove the air supplied to the kitchen areas. This unit (EF-7) utilizes a 100-horsepower fan motor and is also located in Mechanical Room Number 3A-1 on the third floor.

**Air Flow Measurements.** During the field survey, pressure measurements were made on either side of the fans along with fan speed (RPM). Airflows were calculated using this information and manufacturer's performance data. The results of these calculations are contained in Table 2.2-3 below and compared to the original design values and current requirements per MIL-HDBK-1191, DOD, Dental and Medical Treatment Facilities, Design and Construction Criteria, October 1991. These outside air values also greatly exceed ASHRAE 62-89 which are based on occupancy. The design requirements by type of area served are shown in Table 2.2-4.

**Table 2.2-3. Air Flow Calculations**

| | SUPPLY AIR (cfm) | | | |
|---|---|---|---|---|
| SF | DESIGN | MEASURED | REQUIRED[1] | CALCULATED AIR CHANGES (AC)/HR |
| 1 | 69,000 | 79,000 | 67,974 | 4.9 |
| 2 | 74,000 | 91,000 | 72,000 | 4.0 |
| 3 | 61,000 | 79,000 | 58,200 | 4.0 |
| 4A | 83,000 | 107,000 | 77,115 | 4.0 |
| 4B | 83,000 | 102,000 | 77,955 | 4.0 |
| 5 | 14,400 | 17,000 | 12,960 | 6.0 |
| 6 | 27,900 | 32,000 | 24,750 | 8.25 |

Table 2.2-3 Air Flow Calculations (Continued)

| SF | OUTSIDE AIR (cfm) DESIGN | MEASURED | REQUIRED[1] | CALCULATED AIR CHANGES (AC/HR) |
|---|---|---|---|---|
| 1 | 24,840 | 15,010 | 16,600 | 1.25 |
| 2 | 26,640 | 17,290 | 18,000 | 1 |
| 3 | 21,960 | 15,010 | 14,600 | 1 |
| 4A | 20,750 | 31,030 | 24,100 | 1.25 |
| 4B | 20,750 | 37,740 | 24,100 | 1.25 |
| 5[2] | 14,400[2] | 17,000[2] | 4,419[2] | 1.75[2] |
| 6[2] | 32,000[2] | 32,000[2] | 8,250[2] | 2.75[2] |

(1) Minimum per MIL-HDBK-1191, DoD, Dental and Medical Treatment Facilities, Design and Construction Criteria, October 1991.
(2) These are 100 percent outside air units.

Design condition data were obtained from the equipment nameplates and the as-built drawings. Current outside air percentages were calculated using the outside air temperature, return air temperature and mixed air temperature of each AHU measured during the field survey.

Building pressurization measurements were made at the fourth floor entrances and the third floor loading dock. All measurements showed a slight (0.01 to 0.04 inches of water) negative building pressure with respect to outdoors. Buildings are usually designed to maintain positive pressure with respect to outdoors to prevent infiltration of unconditioned outside air.

All supply air flows greatly exceeded both design and required minimums. Maintenance personnel had told us that many AHU airflows had been increased in an effort to increase comfort cooling due to increasing internal loads.

Outside air flows greatly exceed minimum requirements for SFs 4A, 4B, 5 and 6. SFs 5 and 6 are 100 percent OSA units serving the Intensive Care Unit and OR suites, respectively. Reducing OSA to these units would require a return air system. This is impractical because the exhaust air vents are located on the side opposite

the OSA intakes for both units. However, OSA airflows can be reduced on SFs 4A and 4B and these savings are addressed in ECO #HS-18.

**Table 2.2-4. HVAC Requirements**

| AREA TYPES | MINIMUM AIRFLOWS (AC/HR) SUPPLY | OUTSIDE AIR (OSA) |
|---|---|---|
| Clinics, exam rooms | 4 | 2 |
| Administrative | 4 | 1 |
| Patient Bedrooms | 4 | 2 |
| Critical and Sensitive | | |
| General Surgery[1] | 15 | 5 |
| Labs | 6 | 2 |
| ICU | 6 | 2 |
| Surgery Support | 6 | 2 |
| Support | | |
| Dining | 12 | 2 |
| Toilets | 10 | - |
| Hallways | 4 | 1 |
| Computer | 4 | 1 |
| Kitchen | 10 | 2 |
| Physical Therapy | 6 | 2 |

**Note:**

(1) Relative humidity 50 percent to 60 percent.

Source: MIL-HDBK-1191, Department of Defense, Dental and Medical Treatment Facilities Design and Construction Criteria.

**Hot Water System**

Hot water is produced via steam-to-hot water heat exchangers located in the EAMC second floor mechanical room. Hot water is pumped to reheat coils in the various areas throughout the hospital. Local room thermostats control hot water valves to maintain space temperatures. Figure 2.2-3 shows the hospital steam supply process.

**Boilers**. Steam is generated by three D-Type boilers manufactured by International Boiler Company and installed in 1976. Each has a nominal steam generation capacity of 15,400 lbs/hr (~15 MBtu/hr). All three units are single burner, dual fuel (natural gas and No.2 fuel oil), designed for 150 psig, and intended for operation at 125 psig to support turbine-driven chillers. The turbine-driven chillers have since been removed.

## EISENHOWER ARMY MEDICAL CENTER

### Hospital Steam Supply Diagram

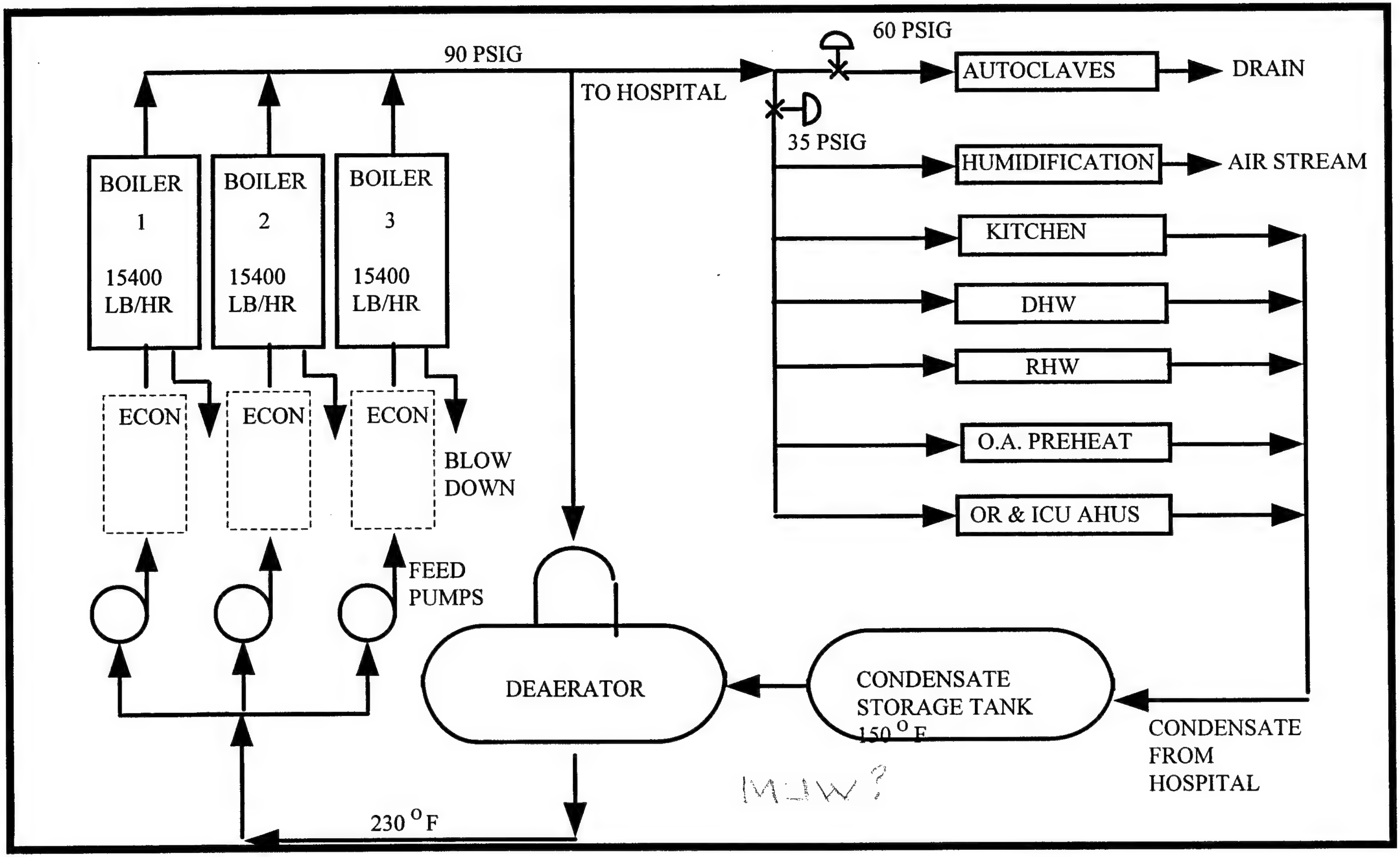



**Figure 2.2-3**

The boilers now operate at 75-90 psig supplying steam to the hospital (see Hospital Loads below for steam uses); and to the adjacent barracks for space heating and domestic hot water. Condensate from both locations is returned. Natural gas is used almost exclusively. Typically, only one boiler is needed to meet loads. The peak winter demand has never required more than two boilers. This was confirmed when we reviewed the boiler operating logs. Figure 2.2-4, which was generated from boiler log data, shows that only in the coldest weather would more than one boiler be required.

The boilers appear to be in generally good condition. The boiler area was clean and neat. The operators reported that during a recent boiler shutdown, the boiler tubes were visually inspected internally and found to be in good condition. There has never been a tube leak in any of the boilers.

We did, however, note many problems with boiler operation. The boiler steam pressure is changing rapidly (spiking) resulting in sudden demand for, or reduction of, steam flow. The magnitude of the steam flow change can be as much as 40 percent of boiler capacity. The frequency of these episodes are as often as four to six times per hour and continue around the clock. (On a survey trip in June 1996, cycles with periods of 40 seconds were observed.) A review of past boiler recorder charts reveal that this phenomena has been occurring for many months. This continual spiking is causing drum level swings that can become nearly unmanageable. Often, the operator must put another boiler into service to dampen the swings to regain control of the drum level. The air flow and fuel flow are swinging with each spike.

Operators report carryover problems. The exact cause is not determinable due to the severe cycling of the boilers. There appears to be steam regulation problems with 35 psi pressure reducing valves in the hospital. They may not be properly controlling the pressure in the 35 psi header system. The safety valve in that system is set at 46 psig and often pops to relieve excess pressure. That problem, coupled with the poor state of the boiler controls, makes it very difficult to determine the extent to which either is contributing to the carryover.

All boilers and associated controls are to be replaced as part of the FY96 Renovation Project.

**Feedwater**. The feedwater is nearly out of control. The drum level is swinging between 15 percent and 85 percent of the site glass range. The feed water valve is not modulating; it is either open or closed. This "on/off" feedwater operation slug feeds the steam drum with relatively cold water. Normal drum water level is two inches below the center line of the drum. A properly operating drum level control loop should control the drum level to within $\pm$ one inch of the normal operating level.

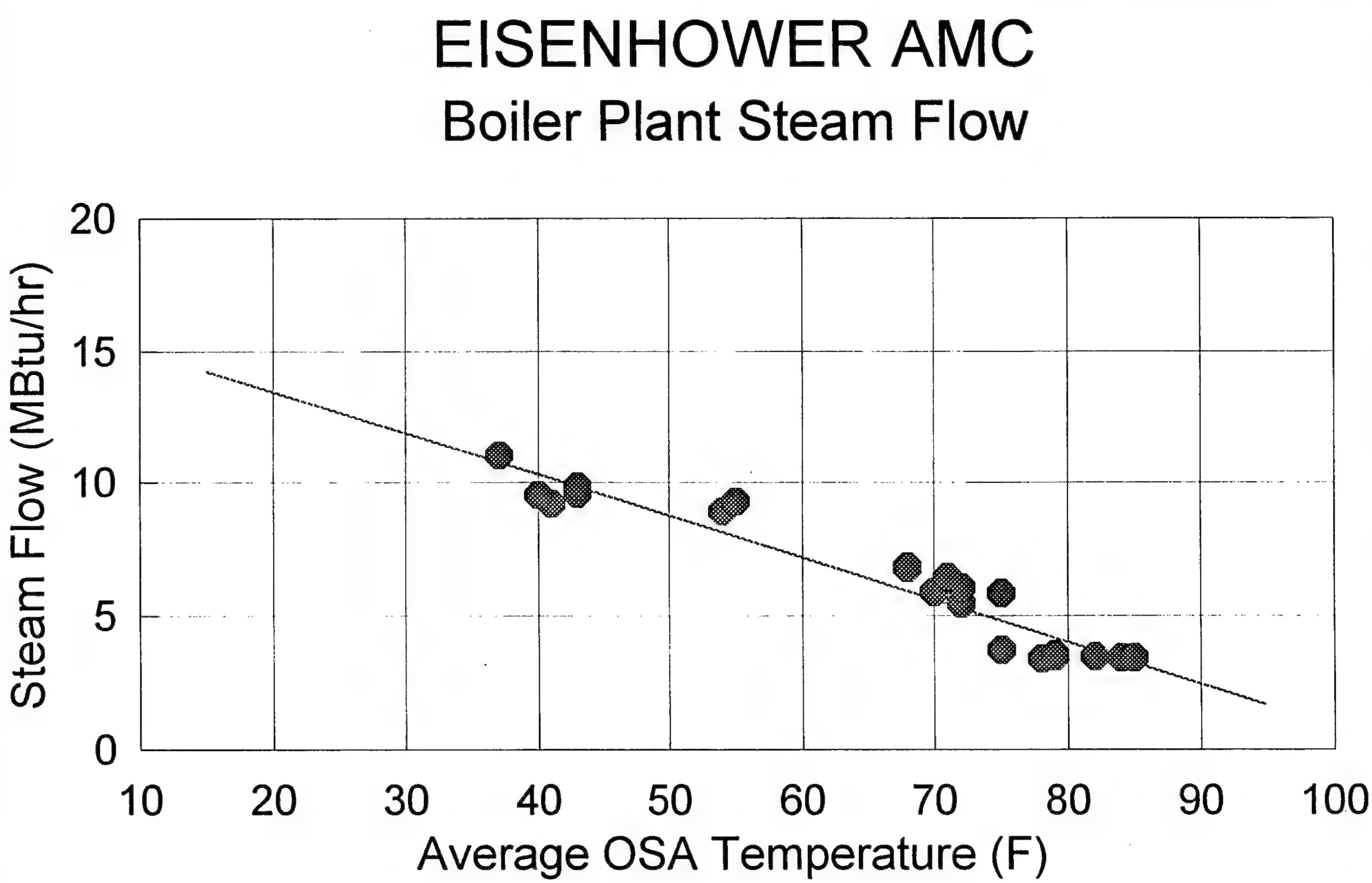

EISENHOWER AMC
Boiler Plant Steam Flow
Steam Flow (MBtu/hr)
0
5
10
15
20
10
20
30
40
50
60
70
80
90
100
Average OSA Temperature (F)

Figure 2.2-4

The feedwater controller on No.3 boiler would not shut off the feedwater flow when the operator manipulated the control station in the control room. In order to control water level in the boiler, he alternately had to allow the drum level to rise until the gauge glass was 85 percent full where the feed water valve would almost close and then run downstairs to blowdown the boiler to bring the water level back down to an acceptable point.

**Combustion Controls**. The operating personnel did not have access to any control logic diagrams or write-up to help them learn how the control system is supposed to control the various boiler parameters. The Fuel Flow/Air Flow ratio adjustment on the control panel did not seem to work on any of the three boilers.

No. 3 furnace pressure control loop is not properly controlling furnace pressure during burner light off and prevents the burner from being lighted. The operators have to take special steps to light off No.3 burner.

**Economizer**. Dedicated economizers were retrofitted to the boilers. ID fans and controls were simultaneously added to overcome the additional gas-side pressure drop created by the added economizer surface. Sootblowers were included to remove ash deposits that accumulate while firing oil.

The economizer installation in these boilers leaves a lot to be desired. The duct transitions to and from the economizer surface provide insufficient duct length to allow the gas to spread out across the face of the economizer. The flow profile through the economizer will be very uneven, heavily skewed toward the center leaving the extremities of the internal surface unheated. This is likely to cause corrosion in the return bends and a reduction in performance.

Furthermore, with the aforementioned feedwater control valve closed, the water in the economizer (if it is in service) can begin steaming. The exit gas temperature from the boiler is >400 degrees F. Steaming in the economizer will cause water hammer in, and perhaps damage to, the economizer.

No.1 economizer is valved out of service with bad leaks. No. 2 economizer was reportedly configured for service, but its supply, discharge and bypass valve were all found wide open. It can't be in service if all three of the valves are open. Its performance temperatures don't correctly indicate in the control room. The lead wire connecting the process thermocouple to the control room read-out device is not a thermocouple lead wire. Any wire other than lead wire matching the thermocouple type (type K in this case) will cause inaccurate readings.

No. 3 economizer is in service with a small leak suspected. Its performance temperatures do not indicate correctly in the control room.

The No. 3 induced draft (ID) fan is vibrating severely after repeated unsuccessful attempts to balance it. It seems that it can be successfully balanced while cold, but promptly goes out of balance when it gets to operating temperature. Operations personnel suspect this fan is metallurgically different from Fans 1 and 2.

All three of the economizers and ID fans are scheduled for removal as part of the FY96 Renovation Project reportedly due to continual leaks and poor overall performance.

**Flue Gas Tests.** All three boilers are equipped with stack $O_2$ sensing equipment in varying states of disrepair. The operators reported that this equipment was removed from service by order of upper management some years ago after a boiler "puff" on Unit 2.

Stack gas measurements taken during a typical drum level swing showed that the excess $O_2$ levels varied from 2.1 percent to 14 percent. This equates to variations in efficiency from 78.3 percent to 58.7 percent. An average value is 68.5 percent. This compares favorably to boiler log recordings. Figure 2.2-5 was developed using steam flow and natural gas logs from the boiler plant for several months of the year. Boiler efficiencies range from 65 percent to 75 percent.

An instrument technician reported that the boiler controls are set to control approximately six percent residual $O_2$ in the stack gas. That is approximately 40 percent excess air and is too high. He reported trying to adjust stack $O_2$ concentration by manipulating the ID fan draft setting. The furnace draft control loop controls furnace draft only and should be set at -0.5 in. w.c. It should never be used to trim stack $O_2$ concentration.

**Water Chemistry.** The boiler water chemistry and testing procedures need some attention. Boiler water pH tests are currently being conducted with litmus paper that does not indicate above a reading of eight. The operators are lulled into believing the pH is about eight because that is what the test procedure tells them it is. Actually, the pH could be anywhere between eight and 14.

The quarterly boiler water analysis conducted by an independent off-site lab consistently indicates the pH is in the range of 12, which is well above the recommended range of eight to 9.5. High pH levels can cause foaming and carryover. The operators have reported occasional carryover problems during heavy steam demands and large load swings. However, they do not believe that the carryover is from foaming. In spite of having operated with high pH for a number of years, visual inspection of the boiler internals indicate no adverse effects. The tubes were reported to be scale free during a boiler inspection in mid 1995.

Additionally, the lab reports sulfite residuals are too low. The addition of sodium sulfite keeps dissolved $O_2$ to a minimum, protecting the ferrous parts from corrosion.

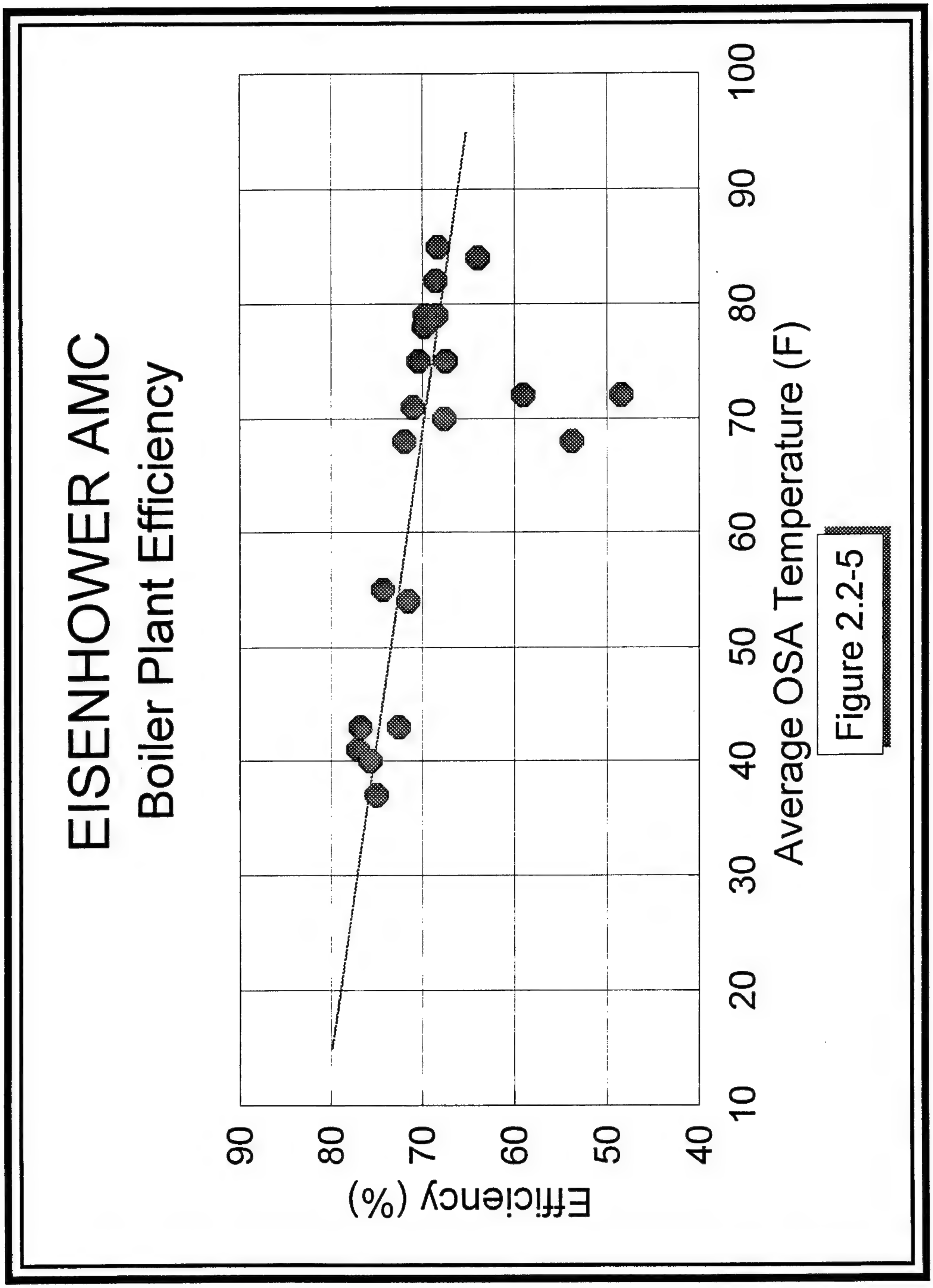

EISENHOWER AMC
Boiler Plant Efficiency
Efficiency (%)
90
80
70
60
50
40
10
20
30
40
50
60
70
80
90
100
Average OSA Temperature (F)

Figure 2.2-5

Boiler total solids is very low indicating that the boiler blowdown is too high. The operators report that they blow down for only ten seconds. A ten second blow may require ten seconds to open the valve, ten seconds to blow and ten seconds to close the valve or thirty seconds total valve open time. This is about as fast as it can be done and still blowdown effectively. The only other option to reduce blow down is to decrease the frequency. This is discussed in Section 4.3.

**Fuel Switching**. When the outside air temperature gets too cold, the gas supply company calls Fort Gordon and advises that natural gas firing should be curtailed. When this happens, all boilers are switched from gas to oil firing.

Typically, the notification sequence is as follows:

- Atlanta Natural Gas calls Energy Management Control (Government) Fort Gordon.
- Energy Management Control calls Central Planning & Control (CPC) (Johnson Controls).
- CPC notifies Building 25910 and all field personnel.
- Building 25910 notifies Boiler Buildings 310, 25330 & 2202.

There have been several problems encountered when trying to fire the boilers on oil. The atomizing steam contains so much water that it is difficult to keep the fuel ignited. This problem is discussed in Section 4.0.

**Feedwater Pumps**. Four, 1/3 capacity feedwater pumps are currently installed. The fourth pump is a spare. The feedwater pump discharge piping is configured to allow either common or boiler dedicated operation. A recirculating, pressure regulating valve has been installed on No.1 pump to keep the pump from "dead heading" against the occasionally closed feedwater control valves. Recommendations for control problems associated with the feedwater pumps are contained in Section 4.3.

**Deaerator.** A single deaerating heater is provided. It operates at six psig supplying 230 degrees F feedwater. The level in the heater is automatically controlled. The deaerator is operating well with no reported problems.

**Condensate Return System**. A single condensate storage tank is installed adjacent to the deaerator to which it is piped directly. The condensate storage tank is operating well with no reported problems. The operating temperature was measured at 150 degrees F.

The only hospital steam consumers that do not return condensate are the autoclaves and humidifying air handlers. It is not practical to recover these losses. Additional water losses in the boiler plant and distribution

system from the boiler blowdown, sootblowing (soon to be eliminated) and general steam and water leaks could be saved. Currently, the boiler water makeup averages 12 percent.

No explanation for the water loss is apparent. The steam supply and condensate return serving the medical barracks were inspected and found to be in good condition. The mechanical rooms were dry and no condensate leaks were found. No obvious steam or condensate leaks were observed in the hospital.

**Hospital Loads.** The hospital uses steam for heating, humidification, domestic hot water, cooking and sterilization. The ten autoclaves require a minimum of 50 psig steam to properly sterilize surgical instruments and equipment. All other uses require 35 psig steam. Typical steam requirements are listed in Table 2.2-5.

**Table 2.2-5. Steam Requirements**

| | CONSUMPTION (lbs/hr) | REQUIRED PRESSURE (psig) |
|---|---|---|
| Kitchen | - | 15-35 |
| Humidification | - | 35 |
| DHW | 4,500 | 35 |
| Space Heating | 0 to 12,000 | 35 |
| Autoclaves (10) | 0 to 860 | 50 |

## 2.3 HISTORICAL ENERGY USE AND COSTS

The EAMC is metered and billed separately from the rest of the installation. The results of this metering are displayed in graphs in this section.

Historical electricity use and demand are shown in Figures 2.3-1 and 2.3-2. Both use and demand have varied little over the past three years. In FY95, the annual electricity consumption was 24,296,400 kilowatt hours, or 82,924 MBtu. The peak demand was in August 1995 at 4,101 kW. The highest demand in the past three years was 4,201 kW in September 1994.

Natural gas use (Figure 2.3-3) shows considerably more variation, especially during the winter months. There appears to be no particular trend in natural gas use over the past three years. The drop in natural gas use in December 1994 was when the boiler plant was operated almost entirely using fuel oil as a test. The natural gas use in FY95 was 696,960 therms or 69,696 MBtu.

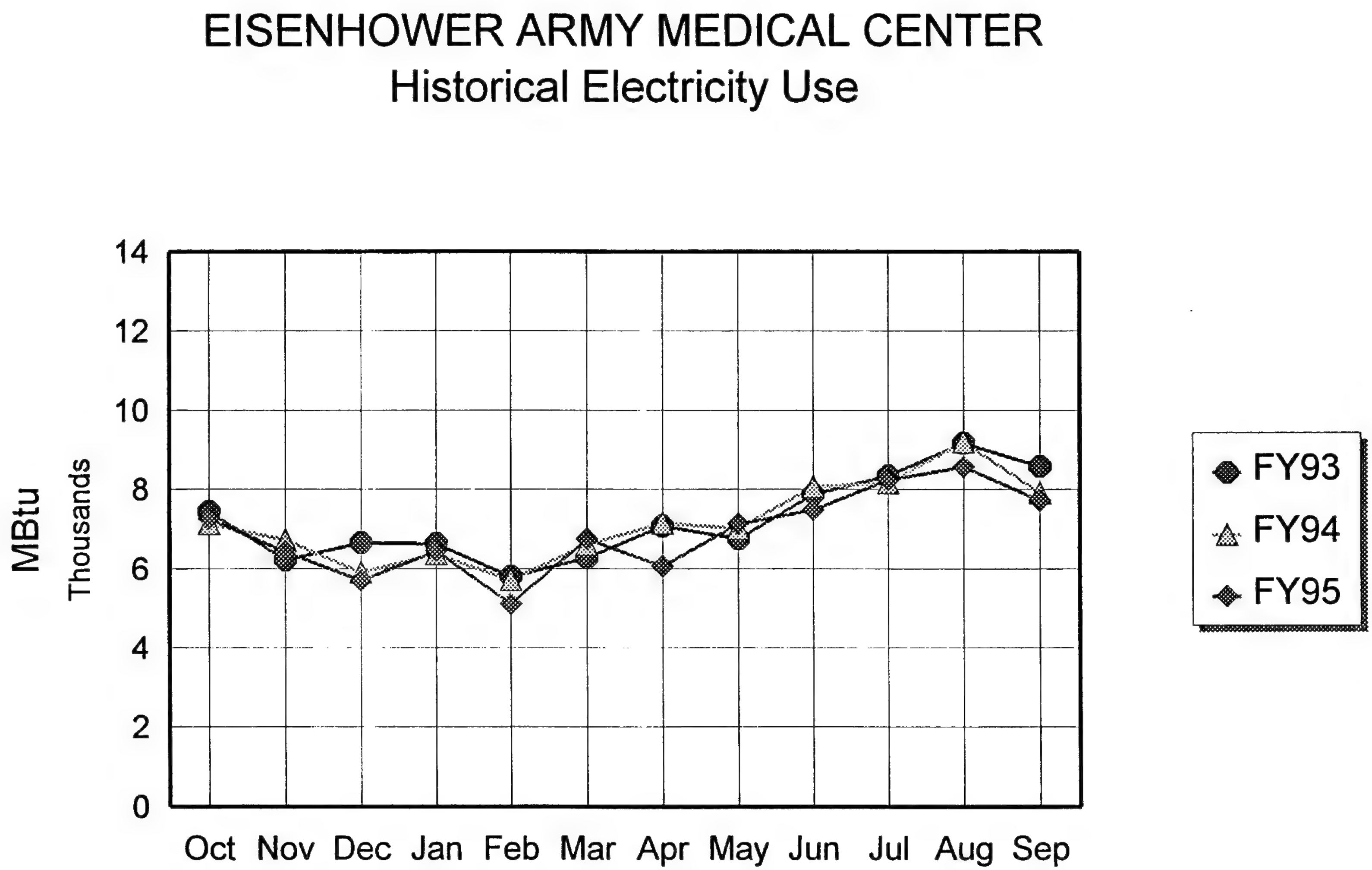

EISENHOWER ARMY MEDICAL CENTER
Historical Electricity Use
MBtu
Thousands
14
12
10
8
6
4
2
0
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep
FY93
FY94
FY95

Figure 2.3-1

## EISENHOWER ARMY MEDICAL CENTER
### Historical Electricity Demand

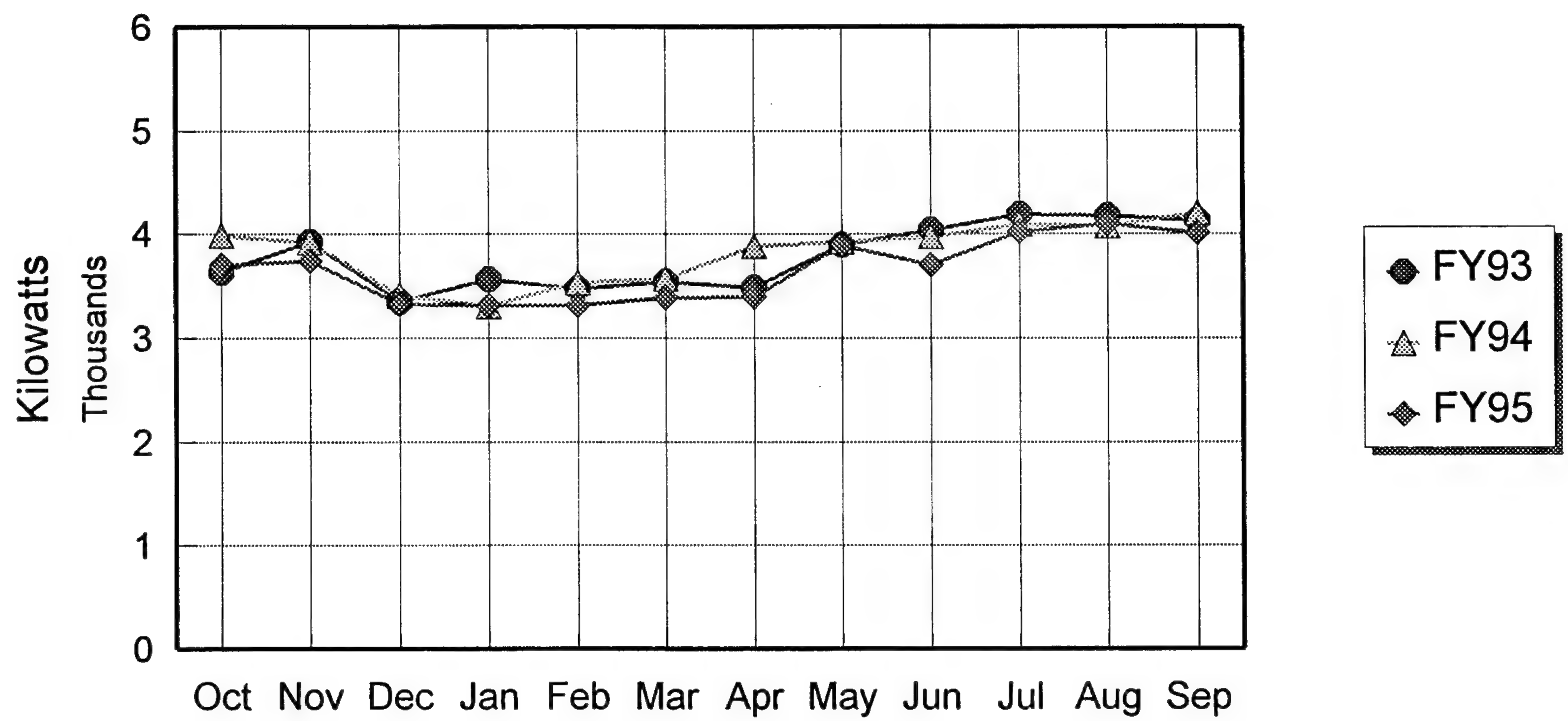



Figure 2.3-2

# EISENHOWER ARMY MEDICAL CENTER
## Historical Natural Gas Use

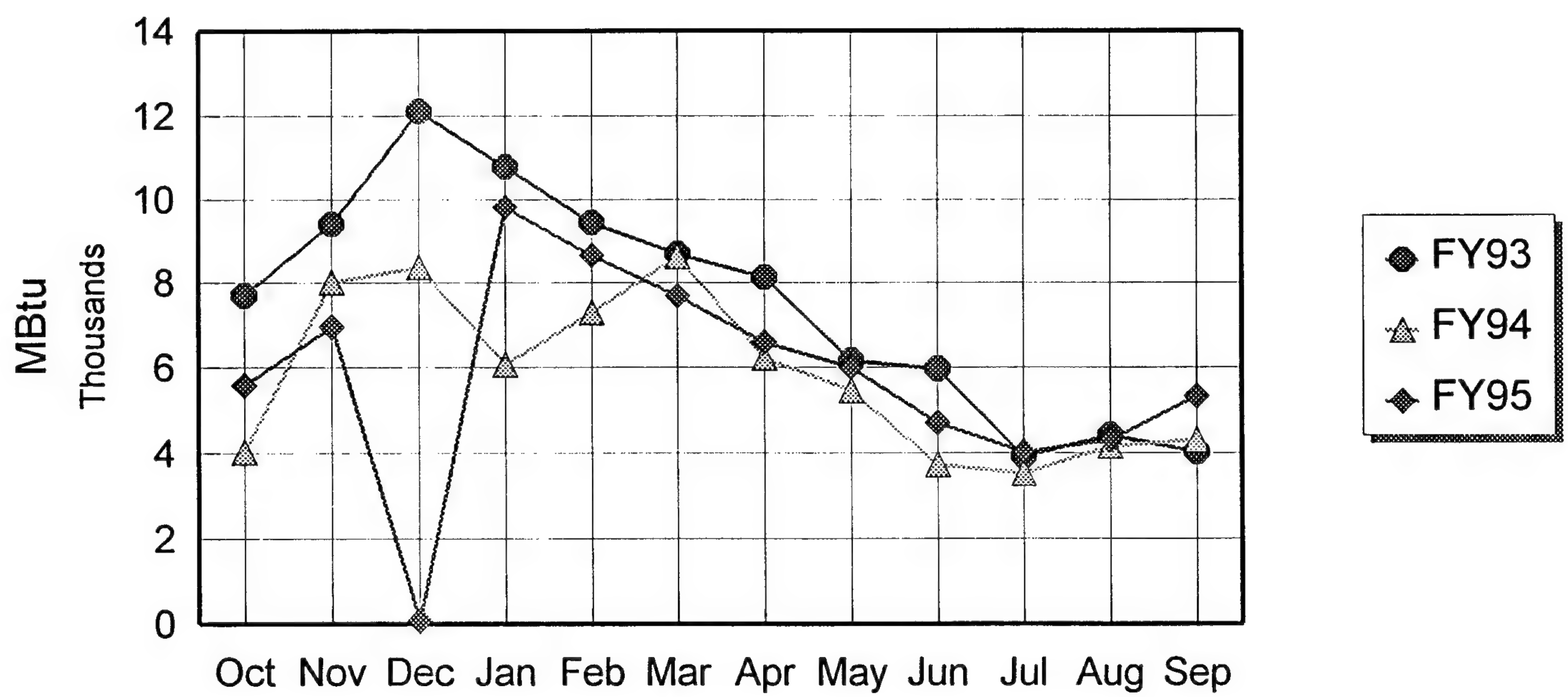


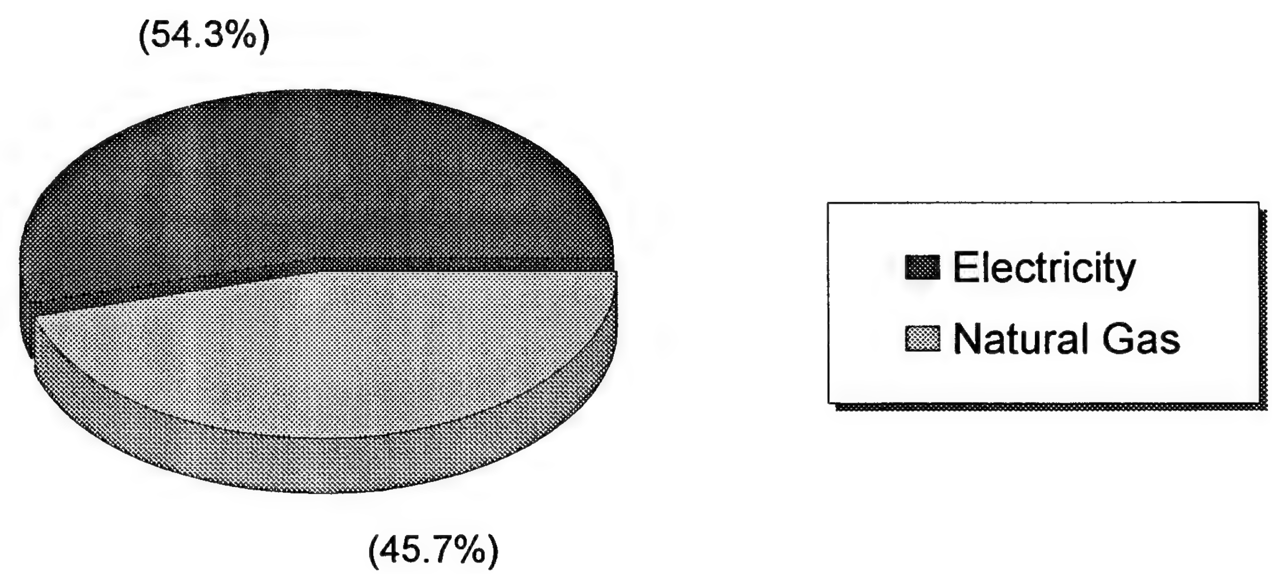

Figure 2.3-3

Figure 2.3-4 shows the energy use breakdown by fuel type for FY95. On a Btu basis, the energy consumption of electricity and natural gas are about equal. The total use for FY95 is 152,619 MBtu, yielding an energy use index (EUI) of 242 kBtu/sf/yr. Energy use has changed little over the past two fiscal years (Figure 2.3-5). The decrease between FY93 and FY94 was primarily due to natural gas use which is weather dependent.

The cost breakdown by fuel type is shown in Figure 2.3-6. Electricity dominates at 85 percent of the $1,266,800 total. The average cost per kWh of electricity is 4.5 cents/kWh. Natural gas averaged 26.8 cents/therm in FY95. Figure 2.3-7 shows total utility costs have varied little over the past two years. Costs are down from FY93 due to decreased natural gas use and prices. The energy cost index (ECI) for FY95 was $2.01/sf.

# EISENHOWER ARMY MEDICAL CENTER

Energy Use by Fuel - FY 95




| | | |
|---|---|---|
| Electricity | 82,924 | MBtu |
| Natural Gas | 69,696 | MBtu |
| Total | 152,619 | MBtu |
| EUI | 242 | kBtu/sf |

Figure 2.3-4

EISENHOWER ARMY MEDICAL CENTER
Historical Utility Consumption

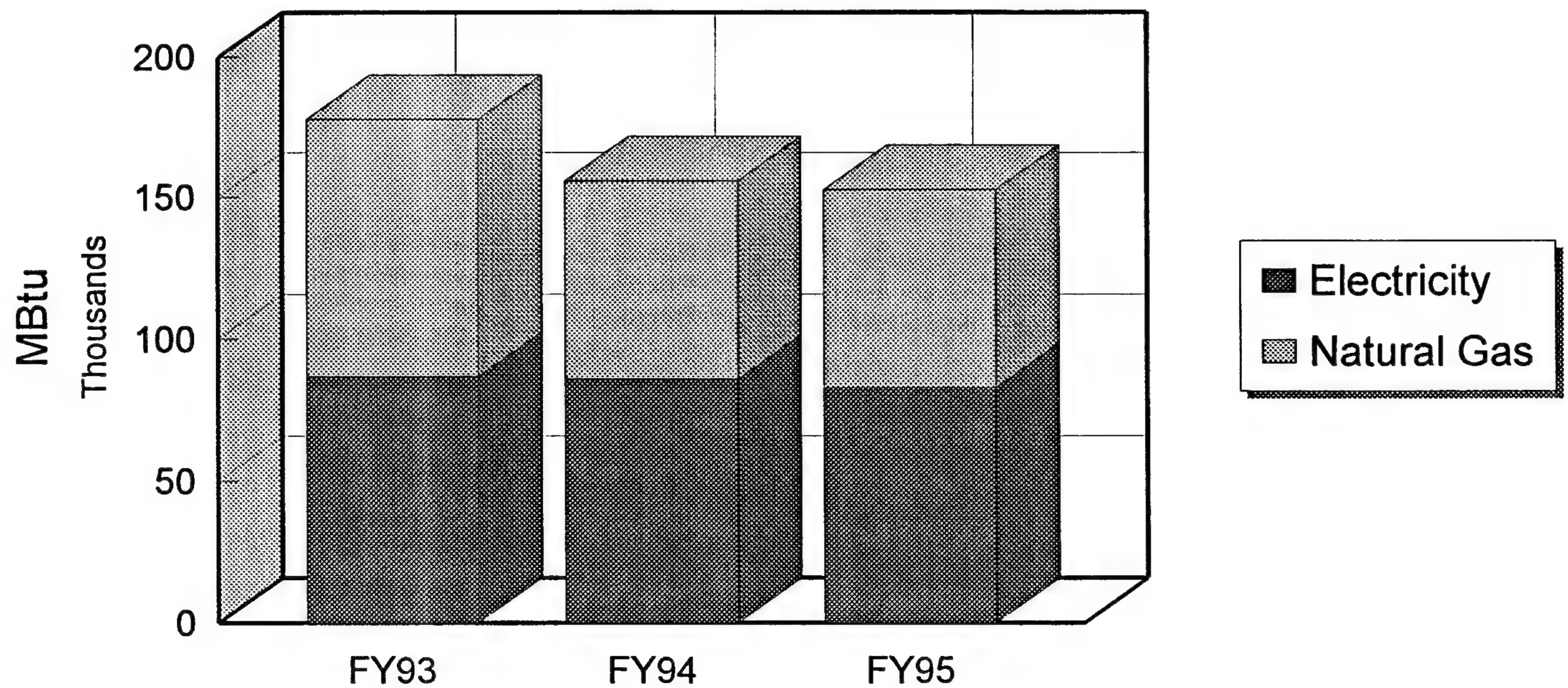
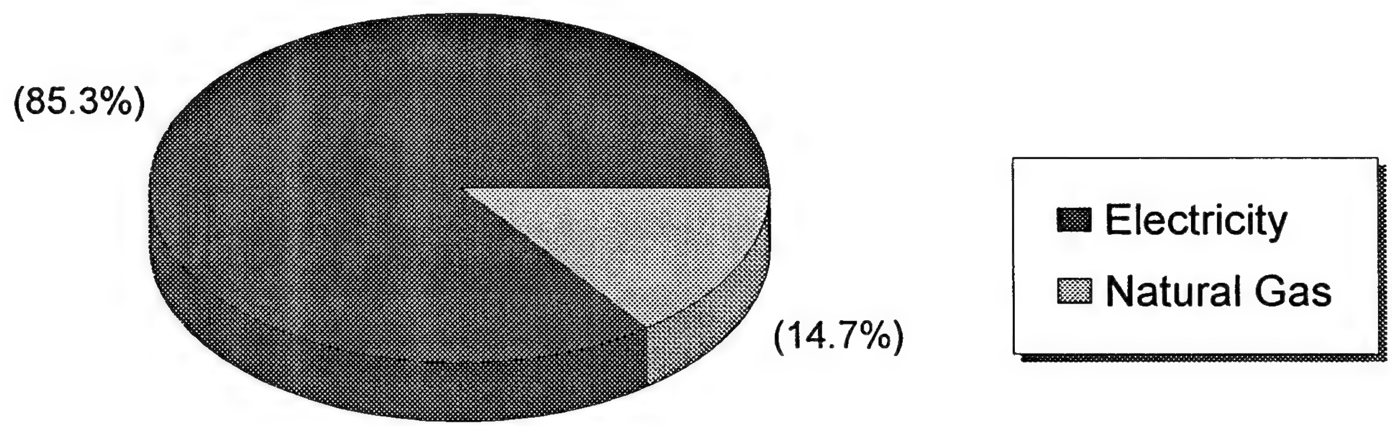



Figure 2.3-5

# EISENHOWER ARMY MEDICAL CENTER

Energy Cost by Fuel - FY 95




| | |
|---|---|
| Electricity | $ 1,080,300 |
| Natural Gas | $ 186,500 |
| Total | $ 1,266,800 |
| ECI | $2.01 /sf |

Figure 2.3-6

EISENHOWER ARMY MEDICAL CENTER
Historical Utility Costs

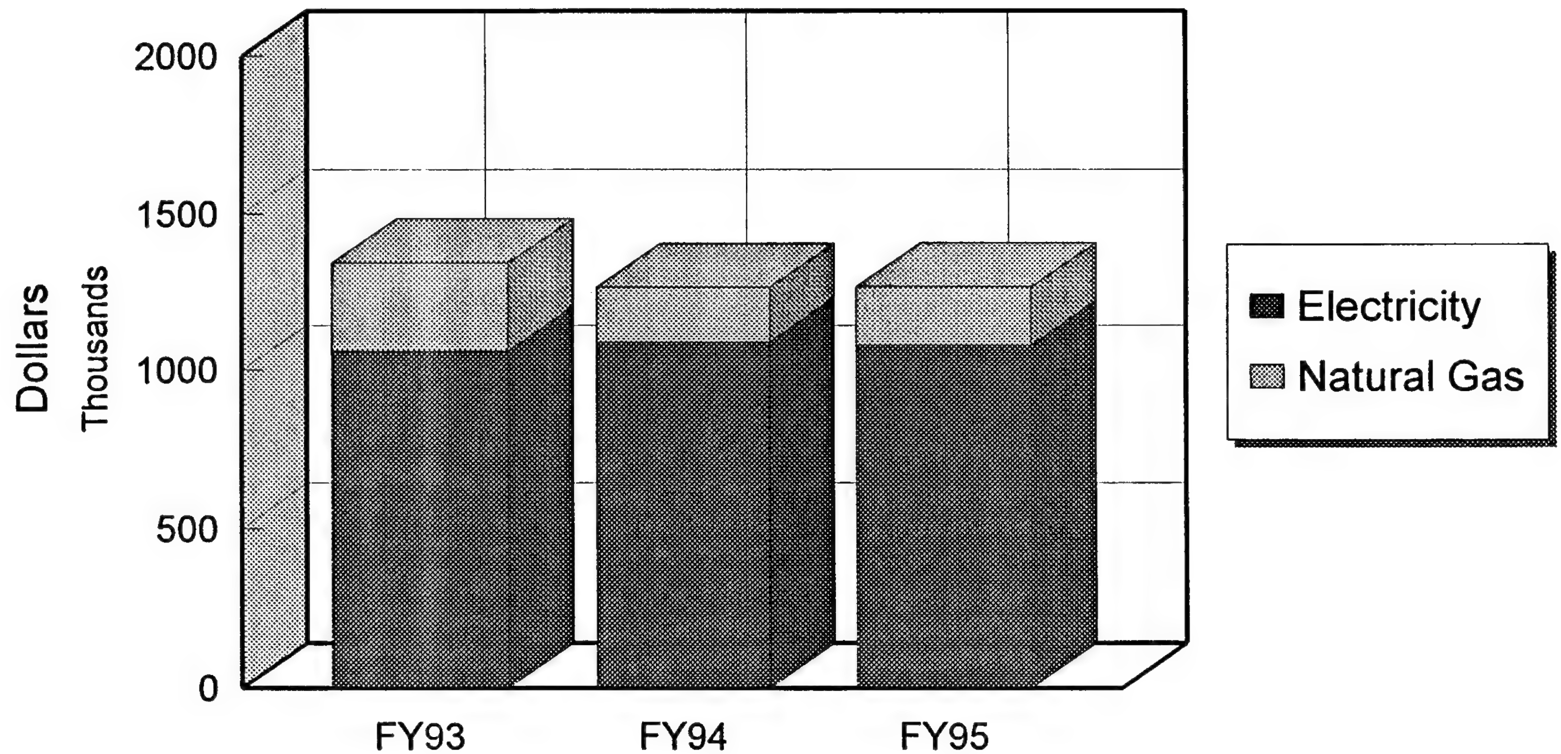



Figure 2.3-7

# 3.0 METHODOLOGY

## 3.1 ANALYSIS TOOLS

The type of analysis used to evaluate the various ECOs will vary with the complexity of the ECO. There are three types of energy analysis software that will be used on this project. These are:

- Lotus 1-2-3®, Release 5
- TRACE 600® Ver. 13.04
- LCCID Ver. 1.0 Level 92

Lotus 1-2-3® is a spreadsheet program preferred by Fort Gordon DPW. RS&H uses this program for energy data analysis and to calculate energy savings for the less complex ECOs.

TRACE 600® is a computer simulation program developed by the TRANE company. It makes hourly calculations to provide building energy use values for space heat and cooling, lighting and other energy using equipment. TRACE 600® can compute energy use of the most complex ECOs that interact with other building systems. Examples of ECOs that may request use of this program are:

- thermal energy storage
- cooling tower retrofits
- peak shaving strategies
- supply air reset
- variable air volume system

Life Cycle Costing in Design (LCCID) is a life cycle cost analysis program developed by Construction Engineering Research Laboratory (CERL) for analysis of DoD energy saving projects. The Level 92 version contains the latest discount factors and fuel escalation rates provided by DOE.

## 3.2 UTILITY RATES AND COST ESTIMATE ADJUSTMENTS

**Utility Rates**

The following utility rate information was used on this project.

Electricity

| | |
|---|---|
| Average Energy | $0.045/kWh ($13.04/MBtu) |
| Peak Demand | $0.80/kW (Summer only) |
| Energy, Incremental | |
| Winter | $0.022/kWh (6.45/MBtu) |
| Summer | $0.035/kWh ($10.25/MBtu) |
| Weighted Average (four months summer, eight months winter) | $0.026/kWh ($7.62/MBtu) |

| | |
|---|---|
| Natural Gas | $2.70/MBtu |

Summer months - June through September
Winter months - All others

Electricity is provided by Georgia Power and natural gas by the Atlanta Gas Light Company. Neither utility offers rebates for energy or demand reduction projects. The EAMC is on a combination of two rates: PLL-2 (Power and Light Large) and SE-7 (Supplemental Energy). The PLL tariff has a declining block structure based on kWh/kW or load factor.

Load factor is the ratio of the kilowatt hours used during the month to the peak demand (in kW) times the hours in the month shown in the equation below:

$$\text{Load Factor} = \frac{E}{D \times H}$$

Where

E = monthly electricity use (kWh)
D = peak demand (kW)
H = hours in month (hrs)

Load factor is a measure of the consistency of the electricity demand or "load" on the utility each month. If the demand is constant, the load factor is 1.00. As the demand drops from its peak, the load factor decreases.

The PLL rate applies to all electricity usage during winter months and summertime electricity usage below the contracted amount of 2,960 kW. SE charges apply to electricity purchases above 2,960 kW which are 3.5 cents/kWh for electricity and $0.80 per kW. The SE rate customers must reduce their demand to the billing demand (2,960 kW for EAMC) upon the request of Georgia Power Company. EAMC accomplishes this by activating two on-site generators (800 kW and 2,100 kW). The 2,960 kW demand is easily met since the EAMC all-time peak is only 4,201 kW. This requires a reduction of only 1,241 kW.

Table 3.2-1 below shows how the price for electricity purchases varies with load factor.

**Table 3.2-1. Electricity Rates Versus Load Factor**

| Winter Load Factor | Winter Rate (¢/kWh) | Summer Load Factor | Summer Rate (¢/kWh) |
|---|---|---|---|
| <0.001 | 12.56 | <0.001 | 12.56 |
| <0.003 | 11.56 | <0.003 | 11.56 |
| <0.007 | 10.11 | <0.007 | 10.11 |
| <0.21 | 8.18 | <0.21 | 8.18 |
| <0.42 | 2.65 | <0.42 | 2.65 |
| <0.64 | 2.41 | <0.62 | 2.41 |
| >0.64 | 2.16 | <0.70 | 2.16 |
| | | >0.70 | 3.48 |

Historically, load factors at EAMC vary from 0.65 in the winter to 0.90 in the summer and average 0.76 year round. Since the EAMC load factor rarely drops below 0.64 in the winter or 0.70 in the summer, the marginal electricity rates are:

| | |
|---|---|
| June - September | 3.5¢/kWh |
| All other months | 2.2¢/kWh |
| Annual Weighted Average | 2.6¢/kWh |
| FY 95 Actual Average | 4.5¢/kWh |

The EAMC has never failed to meet a curtailment request since contracting this rate eight years ago. Typically, 30 to 40 hours of on-site generation are required to meet the contract requirements. This past year, the requests were unusually high, about 76 hours. However, should the EAMC fail to met the curtailment request, there is a substantial penalty. The demand charge portion for the PLL rate would come into effect, which is $8.00 per kW with a 95 percent ratchet of the summer peak. If the EAMC failed to reduce its KW to the billing demand, this would require paying a one-time charge at $8.00/kW for demand in excess of 2,960 kW and 95 percent of that for the next 11 months. For a typical summer time demand of 4,000 kW, this would result in $8,000 additional charges for that month and $83,600 over the next 11 months, for a total cost of $91,600.

**Cost Estimate Adjustments**

The labor rates for all cost estimates were taken from 1996 Means Cost Data Books. Adjustments to cost estimates are shown in Table 3.2-2.

**Table 3.2-2. Cost Estimate Adjustments**

| Adjustments | Labor | Material |
|---|---|---|
| Contingency | 10.0% | |
| Sales Tax | N.A. | 6.0% |
| FICA/Insurance | 20.0%(1) | N.A. |
| Overhead | 15.0%(1) | |
| Profit | 10.0%(1) | |
| Performance Bond | 1.0%(1) | |
| SIOH | 6.0% | |
| Design Fees | 6.0% | |

(1) Product yields labor increase = 53 percent.

## 3.3 COMPUTER MODEL

A computer model of the EAMC energy consumption was developed using TRANE's TRACE 600® energy analysis software. The baseline model was refined to closely match the energy use for FY95. An average value was substituted for December when fuel oil was used exclusively. As discussed in Section 2.3, electricity use for the three fiscal years has changed little. Natural gas use for FY95 was between that of FY94 and FY93, so this was not an extreme weather year. The results of the model calculations are shown in Table 3.3-1 and Figures 3.3-1, 3.3-2 and 3.3-3 which compare historical values with kilowatt hour use, electricity demand and natural gas use, respectively. Annual energy use calculations by the model were within five percent of the actual metered figures. The computer simulation results show that the Renovation Project should reduce electricity energy use by 9.0 percent and natural gas use by 20.2 percent. These are annual cost reductions of nearly $100,000 per year. The model predicted peak heating and cooling loads of 12,000,000 Btu/hour and 1,600 tons, respectively. From this baseline, estimates of energy use by system were calculated. The results are shown in Figures 3.3-4, 3.3-5, 3.3-6 and 3.3-7.

A second model was developed to characterize the impact of the FY96 Renovation Project discussed in Section 2.1. Comparison between the baseline electricity use, electricity demand and natural gas use are show in Figures 3.3-8, 3.3-9 and 3.3-10. Energy reductions are about ten percent for both electricity and natural gas use. This model is the baseline for all ECO evaluations.

**Table 3.3-1 Computer Simulation Results**

| Description | Electricity (kWh/yr) | Electricity Difference | Natural Gas (MBtu/yr) | Natural Gas Difference |
|---|---|---|---|---|
| Metered (FY95) | 24,296,400 | -- | 78,011 | -- |
| Baseline | 24,538,100 | 1.0% (2) | 74,850 | -4.0% (2) |
| After RP (1) | 22,118,900 | -9.0% (3) | 62,200 | -20.2% (2) |
| Cost Savings for RP | $56,900 | | $42,500 | |
| TOTAL | | $99,400 | | |

(1)FY96 Renovation Project and T-8 lamping.
(2)Baseline model relative to metered.
(3)Renovation Project model relative to baseline.

Details of the two models are contained in Volume II. Input echos plus selected outputs can be found there. All ECO evaluations are performed using the second model which contains the improvements funded by the FY96 Renovation Project.

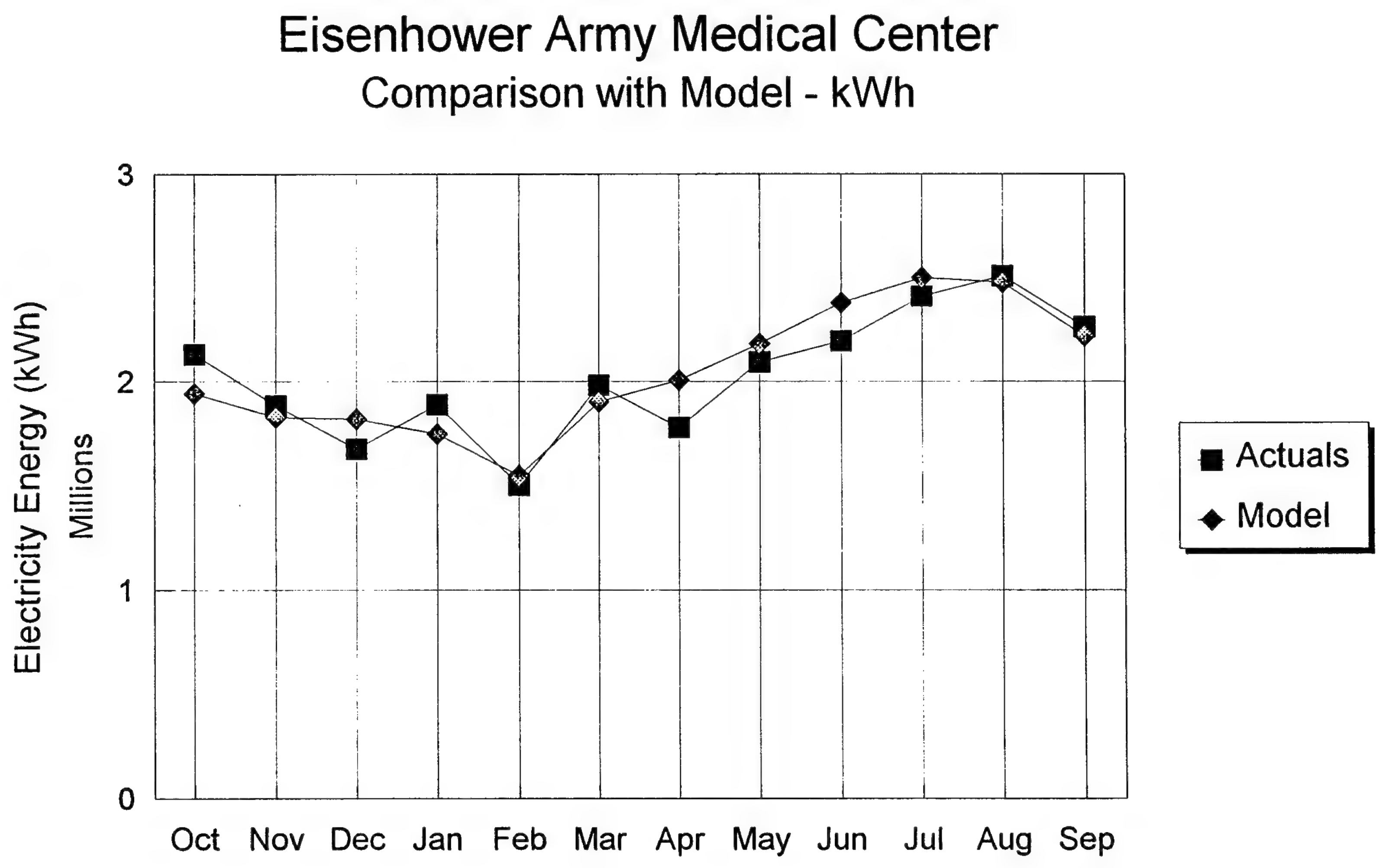

Eisenhower Army Medical Center
Comparison with Model - kWh
Electricity Energy (kWh)
Millions
3
2
1
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Actuals
Model

Figure 3.3-1

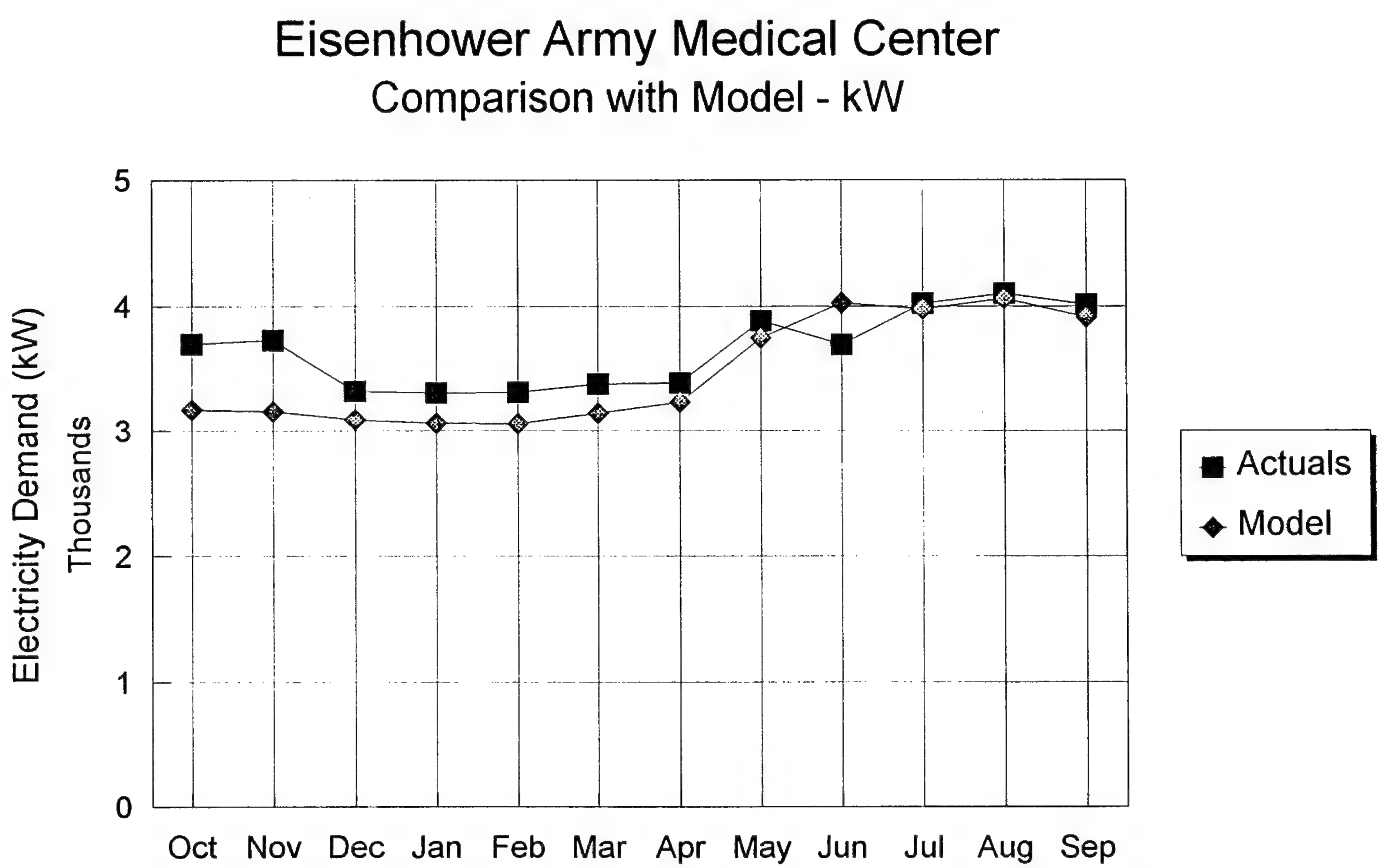
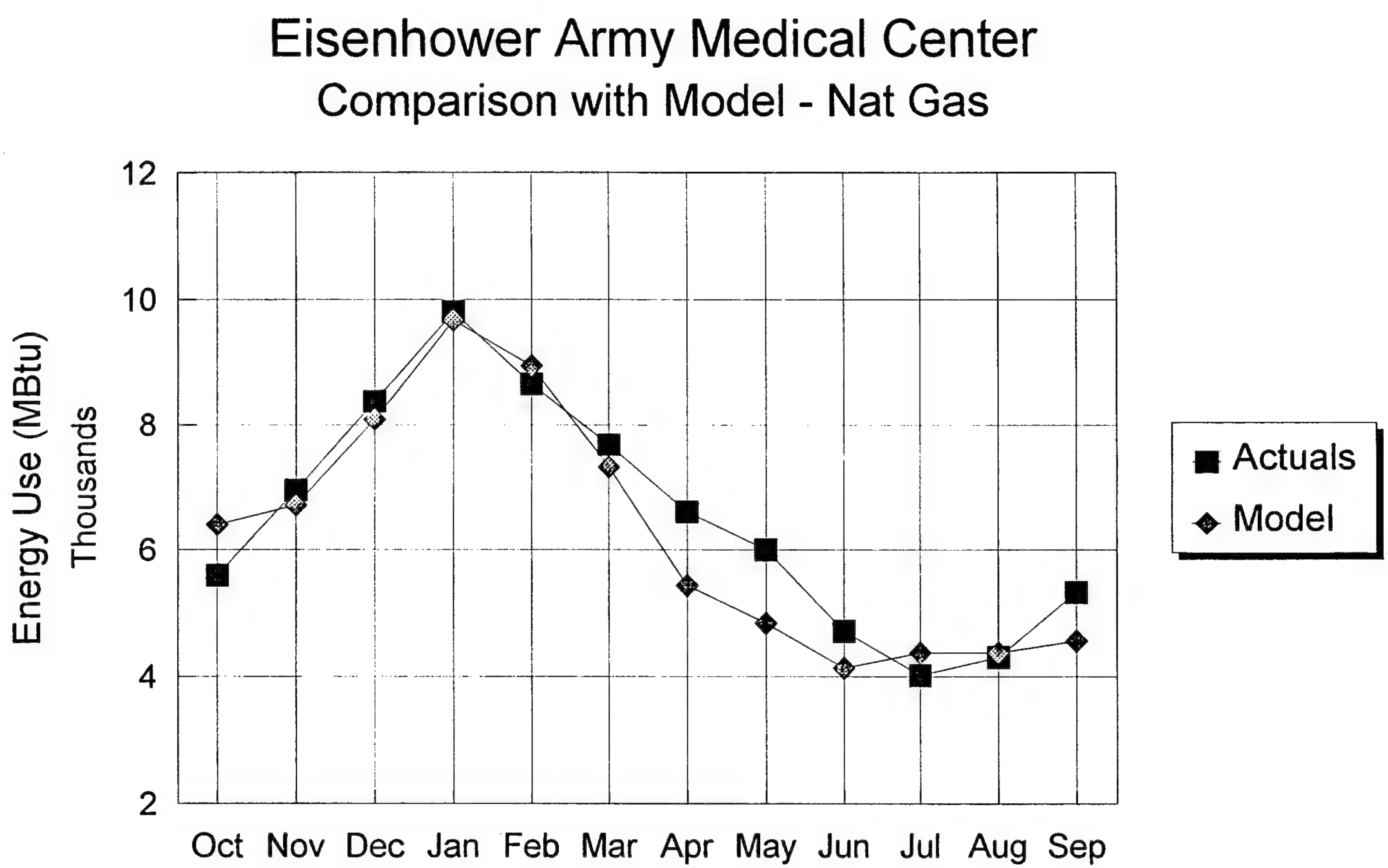

Eisenhower Army Medical Center
Comparison with Model - kW
Electricity Demand (kW)
Thousands
5
4
3
2
1
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Actuals
Model

Figure 3.3-2



Eisenhower Army Medical Center
Comparison with Model - Nat Gas
Energy Use (MBtu)
Thousands
12
10
8
6
4
2
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Actuals
Model


Figure 3.3-3

# EISENHOWER ARMY MEDICAL CENTER

Energy Use by System - Electricity

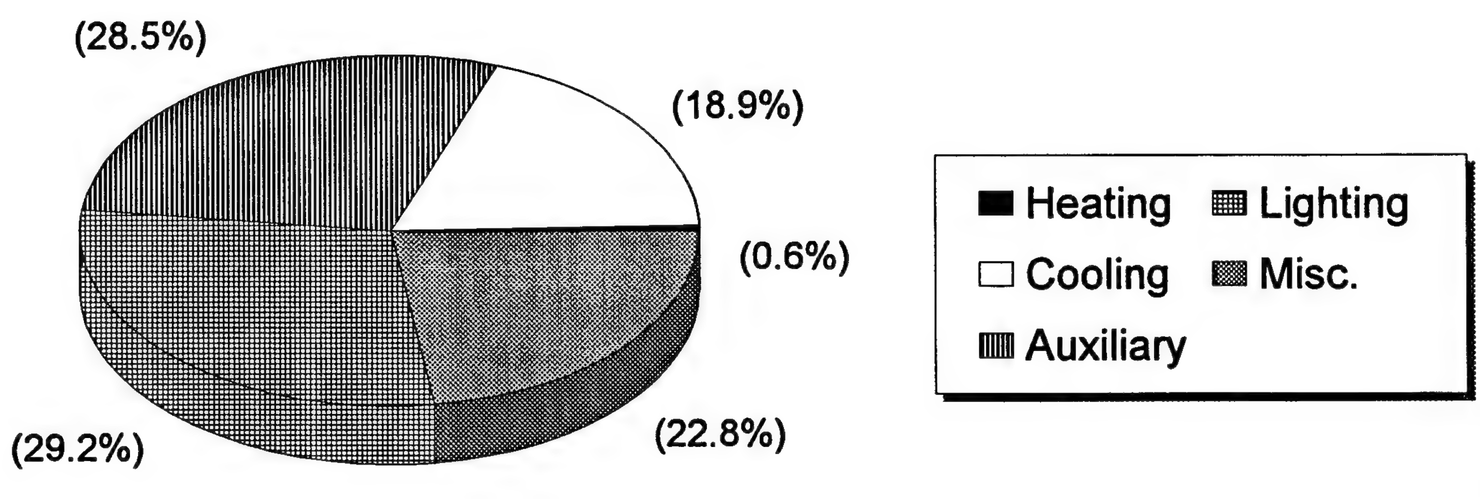



Figure 3.3-4

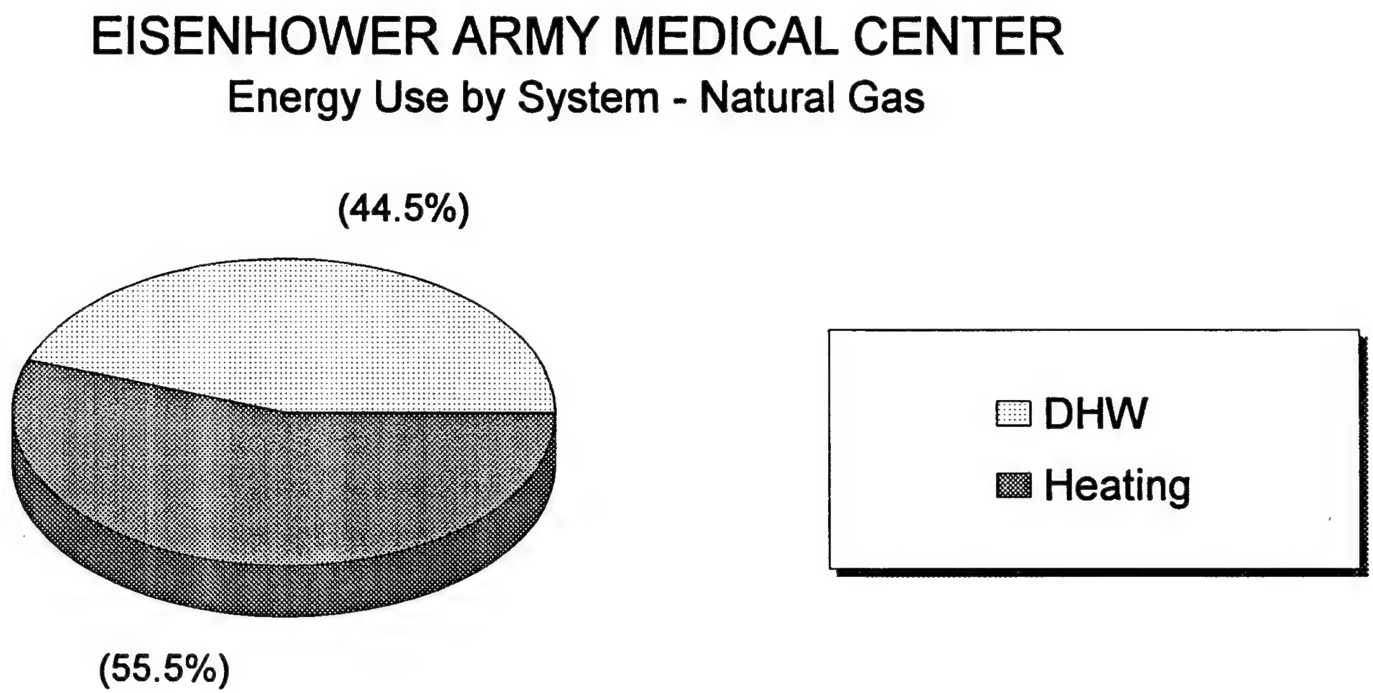

EISENHOWER ARMY MEDICAL CENTER
Energy Use by System - Natural Gas
(44.5%)
(55.5%)
DHW
Heating

Figure 3.3-5

# EISENHOWER ARMY MEDICAL CENTER

Energy Use by System - All Fuels

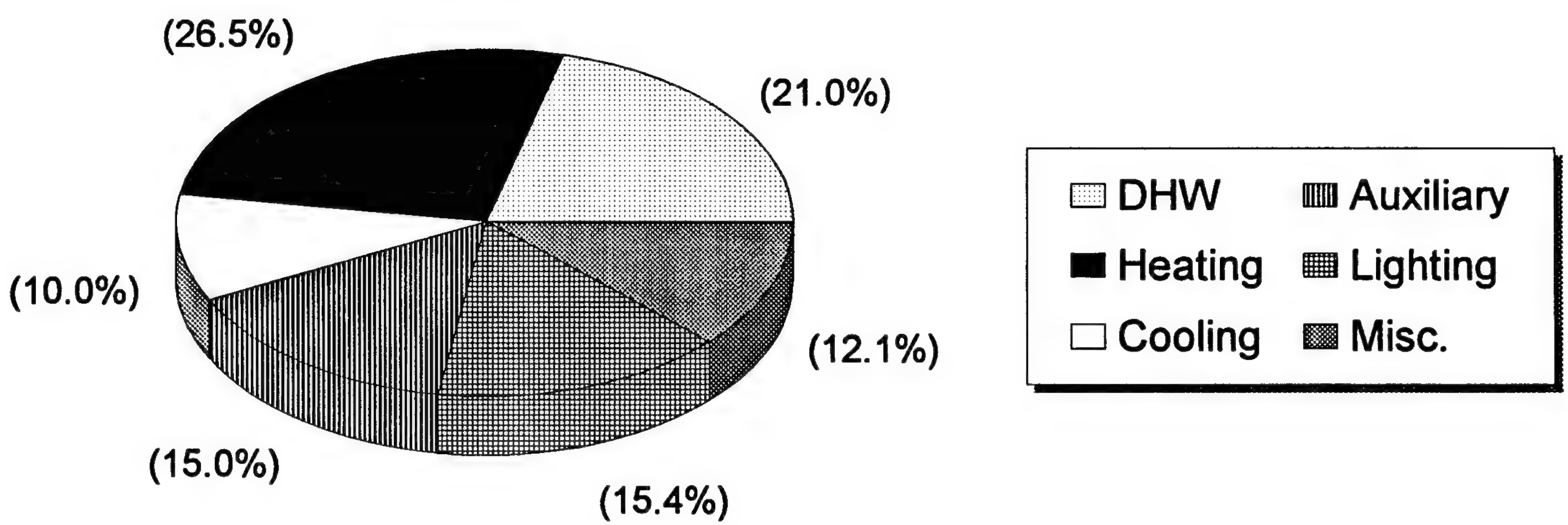



Figure 3.3-6

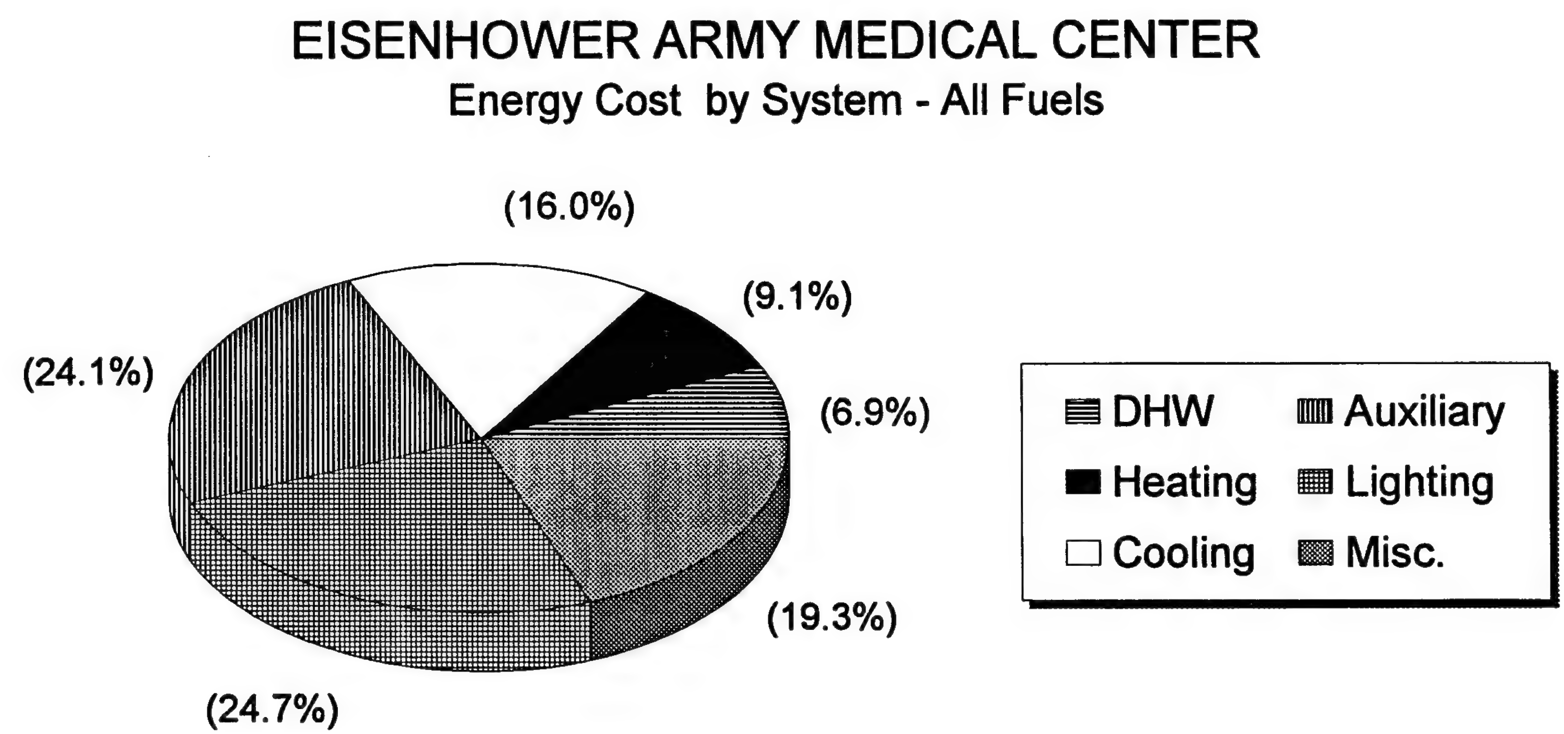

EISENHOWER ARMY MEDICAL CENTER
Energy Cost by System - All Fuels
(16.0%)
(9.1%)
(24.1%)
(6.9%)
(19.3%)
(24.7%)
DHW
Auxiliary
Heating
Lighting
Cooling
Misc.

Figure 3.3-7

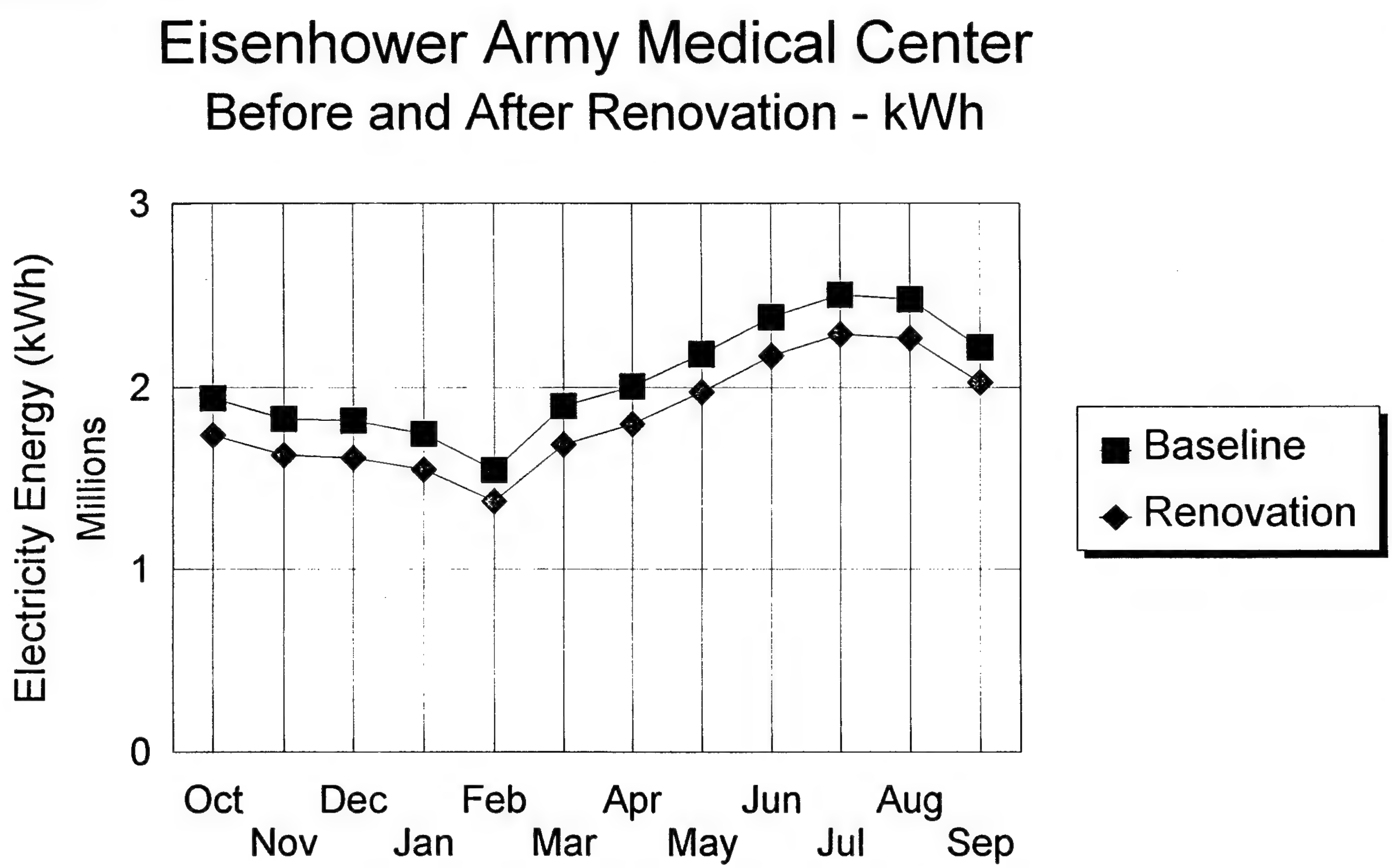
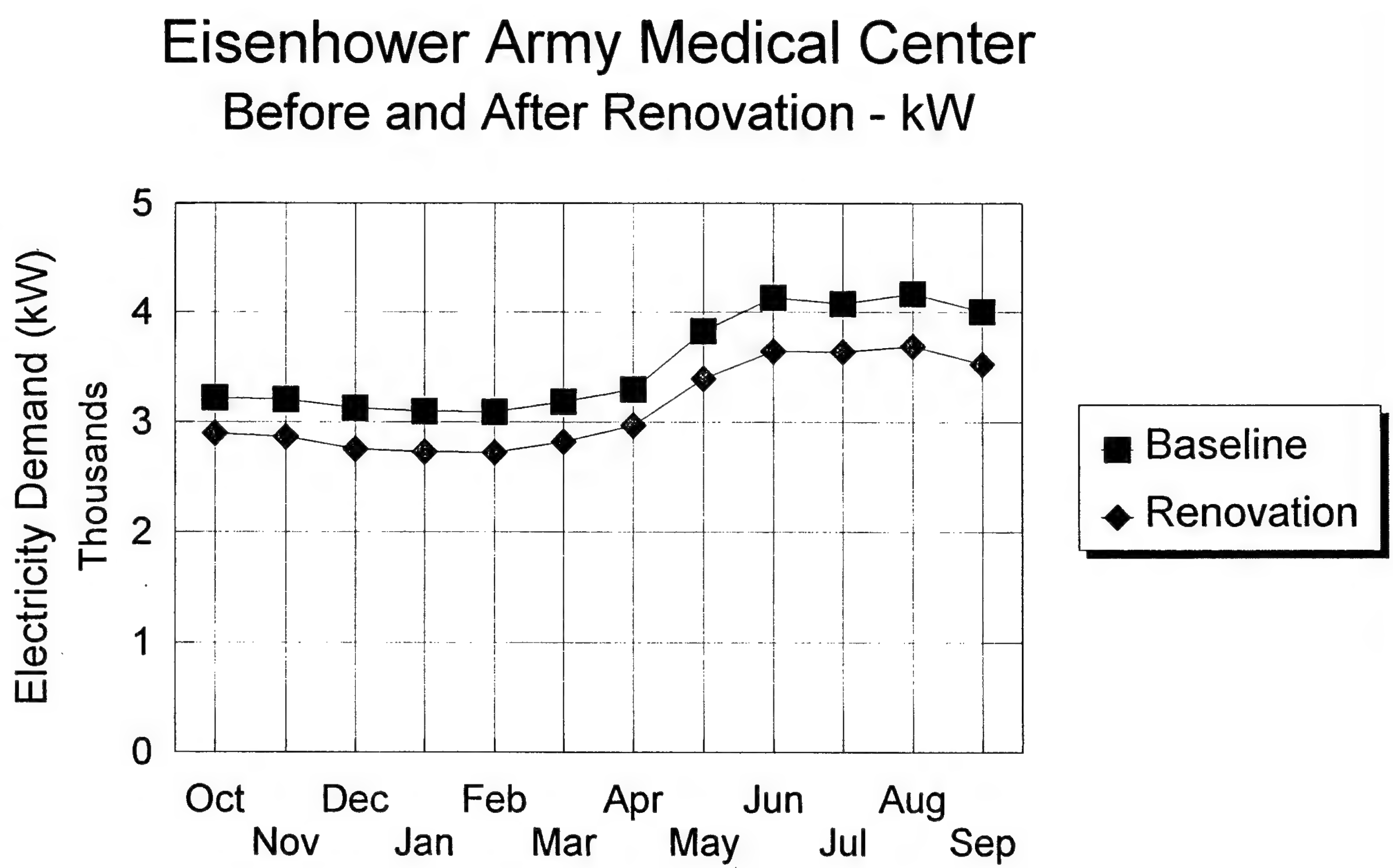

Eisenhower Army Medical Center
Before and After Renovation - kWh
Electricity Energy (kWh)
Millions
3
2
1
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Baseline
Renovation

Figure 3.3-8



Eisenhower Army Medical Center
Before and After Renovation - kW
Electricity Demand (kW)
Thousands
5
4
3
2
1
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Baseline
Renovation


Figure 3.3-9

## Eisenhower Army Medical Center

### Before and After Renovation - Nat Gas

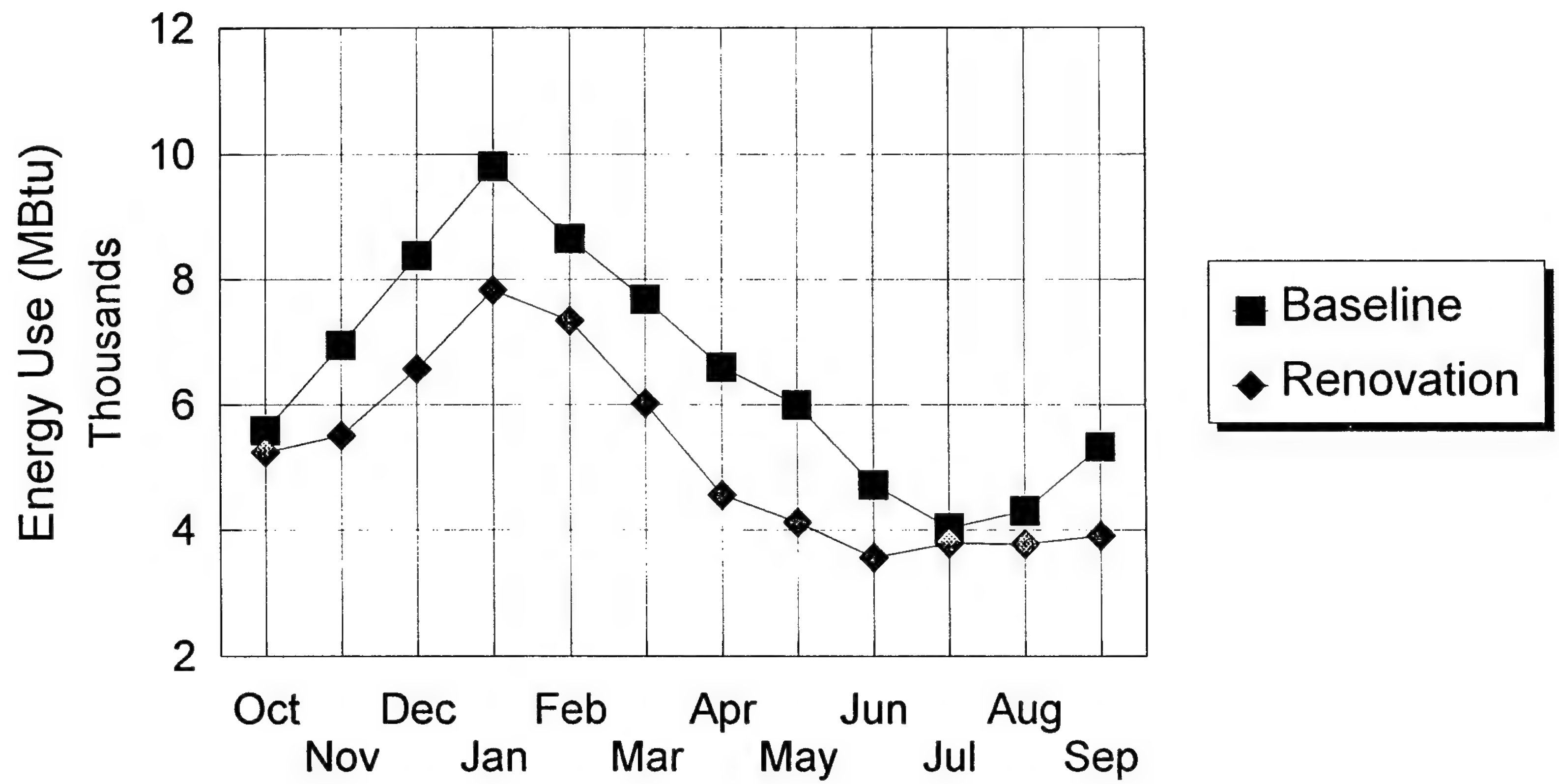



Figure 3.3-10

# 4.0 ANALYSIS

## 4.1 ENERGY CONSERVATION OPPORTUNITY (ECO) EVALUATIONS

The applicability for further study was evaluated for each of the ECOs listed in the scope of work and others added later as a result of the field investigations. A summary of this evaluation is contained in Table 4.1-1.

A detailed analysis was performed for each of those ECOs which were designed to be "evaluated". All analyses were performed assuming that the FY96 Renovation Project and ongoing T-8 retrofit project were completed. However, between the Interim and Prefinal Submittals, the renovation project was expanded to include replacement of all three boilers and associated controls. Therefore, some boiler improvement ECOs were evaluated but are not recommended. If the ECO failed to pay back within ten years, it will not qualify for funding. However, some ECOs that are unlikely to pay back within ten years, such as those involving substantial cost in replacing functioning equipment, are also discussed in this section. Projects that have already been funded as part of the FY96 Renovation Project are so noted. Operation and Maintenance (O&M) projects are described in Section 4.3.

The results of the detailed analyses are summarized in Tables 4.1-2, 4.1-3, and 4.1-4. Table 4.1-2 contains the evaluated ECOs in alphabetical order by ECO ID. Tables 4.1-3 and 4.1-4 display the results ordered by SIR and by payback, respectively.

Table 4.1-5 lists those ECOs qualifying for funding. These ECOs have SIRs greater than 1.25 and paybacks less than ten years. Those ECOs not meeting these requirements are listed in Table 4.1-6. Detailed calculations, cost estimates and Life Cycle Cost Analysis results are located in Volume II, Appendices.

An Energy Management Control System was not evaluated since the FY96 Renovation Project includes a new Plant Management System which encompasses the central heating and cooling plant and the hospital.

TABLE 4.1-1 POTENTIAL ENERGY CONSERVATION OPPORTUNITIES
EISENHOWER ARMY MEDICAL CENTER
FORT GORDON, GA

| ECO ID | ECO DESCRIPTION | EVALUATED | COMMENTS |
|---|---|---|---|
| **Building Envelope** | | | |
| BE1 | Reduce infiltration by caulking and weatherstripping | | See text - Section 4.3, p.4-54 |
| BE2 | Install insulated glass or double-glazed windows | X | |
| BE3 | Install roof insulation | | Very well insulated, U = 0.058 |
| BE4 | Install loading dock seals | | NA |
| BE5 | Install vestibules on entrances | | See discussion in this section |
| BE6 | Install solar shading, screening, curtains or blinds | | NA - exists |
| BE7 | Install wall insulation | | Well insulated, U = 0.068 |
| BE8 | Install low emissivity windows | | Windows have shades/drapes |
| **Boiler Plant** | | | |
| BP1 | Reduce steam distribution pressure | X | |
| BP2 | Shut off steam to laundry when not in use | | NA - No laundry |
| BP3 | Increase boiler efficiency | X | |
| BP4 | Repair, replace, or install condensate return system | | See discussion in this section |
| BP5 | Insulate boiler and boiler piping | | See text, Section 4.3, p. 4-54 |
| BP6 | Repair and maintain steam lines and traps | | See discussion in this section |
| BP7 | Install economizer | X | |
| BP8 | Install air preheater | X | |
| BP9 | Check boiler water chemistry program | | See Section 4.3, p. 4-54 |
| BP10 | Clean boiler tubes | | Boiler tubes in good condition |
| BP11 | Install blowdown controls | | See discussion in this section |
| BP12 | Modify boiler and chiller controls | X | See BP3 |
| BP13 | Improve water treatment to prevent tube fouling | | See BP9 - No problem with tubes |
| BP14 | Install blowdown heat recovery | | See discussion in this section |
| BP15 | Install oxygen trim controls | X | |
| BP16 | Install pony boiler | | See discussion in this section |
| BP17 | Install new unattended boilers | X | |
| **Chiller Plant** | | | |
| CP1 | Repipe chiller to a common manifold | | NA - exists |
| CP2 | Install multispeed/variable speed cooling tower fans | | Renovation Project |
| CP3 | Replace absorption chillers with centrifugal chillers | | Absorption chiller to be used for peak shaving |
| CP4 | Reduce condensate water temperature | | Renovation Project |
| CP5 | Shut off unneeded circulating pumps | | Renovation Project |
| CP6 | Reduce chilled water flow during light loads | | Renovation will make prim/sec pumping system |
| CP7 | Shed loads during peak electrical demand periods | | NA - Not practical at hospital |
| CP8 | Raise chilled water temperature | | Renovation Project |
| CP9 | Install high efficiency chiller | | Renovation Project |
| **Electrical Equipment** | | | |
| EL1 | Shut off elevators whenever possible | | NA - Not practical at hospital |
| EL2 | Shut off pneumatic tube system whenever possible | | NA - Not practical at hospital |
| EL3 | Install capacitors or synchronous motors to increase power factor | X | |
| EL4 | Use emergency generator to reduce peak demand | X | |
| EL5 | Shed or cycle electrical loads to reduce peak demand | | NA - Not practical at hospital |
| EL6 | Convert to energy efficient motors | X | |
| EL7 | Install variable volume pumping | | Renovation Project |

| | | | |
|---|---|---|---|
| **Heating, Ventilation and Air Conditioning - Systems** | | | |
| HS1 | Use dry bulb economizers | | Renovation Project |
| HS2 | Reduce reheating of cooled air | X | See HS7 |
| HS3 | Use energy recovery units | X | |
| HS4 | Use hot and cold deck temperatures reset | | Renovation Project |
| HS5 | Maintain filters | | Well maintained |
| HS6 | Clean coils | | Renovation Project |
| HS7 | Install variable air volume controls | X | |
| HS8 | Insulate ducts and piping | | See text - Section 4.3, p. 4-54 |
| HS9 | Eliminate simultaneous heating and cooling | X | See HS7 |
| HS10 | Install night setback controls | | Renovation Project |
| HS11 | Replace over-sized motors | | See discussion in this section |
| HS12 | Replace hand valves with automatic ones | | NA |
| HS13 | Use damper controls to shut off air to unoccupied areas | X | |
| HS14 | Shut off or reduce speed of room fan coil units | | NA |
| HS15 | Shut off or reduce stairwell heating | | NA - no overheating, minimal savings |
| HS16 | Reduce AHU air volumes | | See discussion in this section |
| HS17 | Shut off AHU's whenever possible | | Renovation Project |
| HS18 | Reduce heated or cooled OSA | X | |
| HS19 | Reduce humidification to minimum requirements | | Current setting is 40%, below 50% requirement |
| HS20 | Reduce pumping flow | | Renovation Project |
| HS21 | Repair and/or maintain AHU controls | | Renovation Project |
| HS22 | Cycle fans and pumps | | Renovation Project |
| HS23 | Reset thermostats to design requirements | | See text - Section 4.3, p. 4-54 |
| HS24 | Reset surgical suite supply air | X | |
| **Kitchen** | | | |
| KI1 | Shut off range hood exhaust whenever possible | | Renovation Project |
| KI2 | Install high efficiency steam control valves | | NA |
| KI3 | Shut off equipment and appliances whenever possible | | See text - Section 4.3, p. 4-54 |
| KI4 | Install makeup air supply for exhaust | | NA - exists |
| KI5 | Install heat reclamation system for exhaust heat | X | |
| KI6 | Turn off lights in coolers | | See text - Section 4.3, p. 4-54 |
| KI7 | Install heat pump water heater | | NA - Only practical for residential |
| KI8 | Install energy efficient exhaust hoods | X | |
| **Lighting** | | | |
| LT1 | Shut off lights when not needed | | See text - Section 4.3, p. 4-54 |
| LT2 | Reduce lighting levels | X | |
| LT3 | Revise cleaning schedules | | NA |
| LT4 | Convert to energy efficient lighting systems | X | |
| LT5 | Install reflectors in fluorescent fixtures | | See discussion in this section |
| LT6 | Install separate lighting switching | | No large-scale applications |
| LT7 | Analyze the effects of harmonics for electronic ballast system | | See text - Section 4.3, p. 4-54 |
| **Miscellaneous** | | | |
| MI1 | Install computerized EMCS | | Renovation Project |
| MI2 | Convert steam-driven turbine motors to electric | | NA |
| MI3 | Install occupancy sensors to control lighting or HVAC | X | |
| | Use natural gas technology to reduce peak demand, such as | | |
| MI4 | Desiccant cooling | X | |
| MI5 | Direct-fired, double-effect absorption chiller | | Renovation Project |
| MI6 | Convert to Real-Time Pricing electricity rate | | See discussion in this section |
| **Plumbing** | | | |
| PL1 | Reduce domestic hot water temperature | | Current setting is appropriate - 115 F |
| PL2 | Repair and maintain hot water and steam piping insulation | | See text - Section 4.3, p. 4-54 |
| PL3 | Install flow restrictors | | NA - More useful for showers |
| PL4 | Install automatic shut off faucets | | NA - No problem exists |
| PL5 | Decentralize hot water heating | | Impractical |
| PL6 | Add pipe insulation | | See text - Section 4.3, p. 4-54 |

BP16, BP17, CP9, HS24 and MI6 were added as a result of field investigations.

Table 4.1-2 ECO Evaluations Summary - Ordered by ECO ID

| No. | ECO ID | Description | Construction Cost | Annual Savings Energy (MBtu/yr) Elec. | NGas | O&M | Annual Cost Savings | SIR | Simple Payback (yrs) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | BE2 | Install insulated glass or double-glazed windows | $242,000 | 2 | 62 | - | $200 | 0.0 | 999 |
| 2 | BP1 | Reduce steam distribution pressure from 60 to 30 psig | $25,800 | (2,413) | 3,432 | - | ($9,100) | 0.0 | 999 |
| 3 | BP3 | Increase boiler efficiency (repair controls) | $24,000 | - | 6,706 | - | $18,100 | 11.6 | 1.5 |
| 4 | BP7 | Install economizer | $104,100 | (82) | 3,691 | - | $9,300 | 1.4 | 12.5 |
| 5 | BP8 | Install air heater | - | (82) | 3,691 | - | $9,300 | 0.0 | 999 |
| 6 | BP15 | Install oxygen trim controls | $9,900 | - | 640 | - | $1,700 | 2.7 | 6.4 |
| 7 | BP16 | Install pony boiler | $100,600 | - | 517 | - | $1,400 | 0.2 | 80.7 |
| 8 | BP17 | Install new unattended boilers | $427,800 | - | 8,971 | $120,000 | $144,200 | 4.1 | 3.3 |
| 9 | EL3 | Increase power factor | $76,800 | - | - | - | $4,900 | 0.7 | 17.8 |
| 10 | EL4 | Use emergency generator to reduce demand | $182,400 | 15 | (416)* | $65,200 | $67,900 | 3.0 | 4.3 |
| 11 | EL6 | Convert to energy efficient motors | $17,200 | 284 | - | - | $2,200 | 1.5 | 8.9 |
| 12 | HS7 | Install variable air volume controls | $329,600 | 2,472 | 1,880 | - | $23,900 | 0.9 | 15.4 |
| 13 | HS13 | Use damper controls to shut off air to unoccupied areas | $111,500 | 2,041 | 1,505 | - | $19,600 | 2.3 | 6.4 |
| 14 | HS18 | Reduce heated or cooled outside air | $1,100 | 136 | 32 | - | $1,100 | 12.7 | 1.1 |
| 15 | HS24 | Surgical suite supply air reset | $1,400 | 738 | 1,984 | - | $11,000 | 108.0 | 0.1 |
| 16 | KI5 | Install heat reclamation system for exhaust heat | $87,700 | (395) | 2,630 | - | $4,100 | 0.8 | 24.0 |
| 17 | KI8 | Install energy efficient kitchen exhaust hoods | $138,700 | (532) | 4,032 | - | $6,800 | 0.9 | 22.7 |
| 18 | LT2 | Reduce lighting levels | $5,500 | 1,158 | - | - | $8,800 | 19.6 | 0.7 |
| 19 | LT4A1 | Retrofit with T-8s & elect. ballasts - hallways/100 | $5,900 | 90 | - | - | $700 | 1.4 | 9.6 |
| 20 | LT4A2 | Retrofit with T-8s & elect. ballasts - patient rooms/100 | $5,900 | 60 | - | - | $450 | 1.0 | 14.5 |
| 21 | LT4A3 | Retrofit with T-8s & elect. ballasts - offices/100 | $5,900 | 27 | - | - | $200 | 0.4 | 32.1 |
| 22 | LT4B1 | Replace MVs with T-8 fixtures | $830 | 4 | - | $9 | $42 | 0.6 | 22.3 |
| 23 | LT4B2 | Replace MVs with metal halides | $3,150 | 12 | - | ($80) | ($1,030) | 0.1 | 308.3 |
| 24 | LT4C1 | Retrofit compact fluor's in restrooms. | $37,500 | 231 | - | $8,500 | $10,300 | 3.3 | 4.0 |
| 25 | LT4C2 | Retrofit compact fluor's in lobby downlights. | $1,100 | 13 | - | $500 | $600 | 6.6 | 2.0 |
| 26 | MI3A | Install occ. sensors to control lighting- restrooms/100 | $14,900 | 259 | - | - | $2,000 | 1.6 | 8.5 |
| 27 | MI3B | Install occ. sensors to control lighting-breakrooms. | $1,900 | 999 | - | - | $7,600 | 4.9 | 2.8 |
| 28 | MI3C | Install occ. sensors to control lighting- offices/100 | $6,700 | 28 | - | - | $210 | 0.4 | 35.2 |
| 29 | MI3D | Install occ. sensors to control lighting- exam rms/100 | $6,600 | 62 | - | - | $500 | 0.9 | 15.7 |
| 30 | MI4 | Natural gas desiccant cooling | $176,900 | 833 | (2,804) | - | ($1,200) | -0.2 | 999 |

* Fuel oil

Table 4.1-3 ECO Evaluations Summary - Ordered by SIR

| No. | ECO ID | Description | Construction Cost | Annual Savings: Energy (MBtu/yr) Elec. | NGas | O&M | Annual Cost Savings | SIR | Simple Payback (yrs) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | HS24 | Surgical suite supply air reset | $1,400 | 738 | 1,984 | - | $11,000 | 108.0 | 0.1 |
| 2 | LT2 | Reduce lighting levels | $5,500 | 1,158 | - | - | $8,800 | 19.6 | 0.7 |
| 3 | HS18 | Reduce heated or cooled outside air | $1,100 | 136 | 32 | - | $1,100 | 12.7 | 1.1 |
| 4 | BP3 | Increase boiler efficiency (repair controls) | $24,000 | - | 6,706 | - | $18,100 | 11.6 | 1.5 |
| 5 | LT4C2 | Retrofit compact fluor's in lobby downlights. | $1,100 | 13 | - | $500 | $600 | 6.6 | 2.0 |
| 6 | MI3B | Install occ. sensors to control lighting-breakrooms. | $1,900 | 999 | - | - | $7,600 | 4.9 | 2.8 |
| 7 | BP17 | Install new unattended boilers | $427,800 | - | 8,971 | $120,000 | $144,200 | 4.1 | 3.3 |
| 8 | LT4C1 | Retrofit compact fluor's in restrooms. | $37,500 | 231 | - | $8,500 | $10,300 | 3.3 | 4.0 |
| 9 | EL4 | Use emergency generator to reduce demand | $182,400 | 15 | (416)* | $65,200 | $67,900 | 3.0 | 4.3 |
| 10 | BP15 | Install oxygen trim controls | $9,900 | - | 640 | - | $1,700 | 2.7 | 6.4 |
| 11 | HS13 | Use damper controls to shut off air to unoccupied areas | $111,500 | 2,041 | 1,505 | - | $19,600 | 2.3 | 6.4 |
| 12 | MI3A | Install occ. sensors to control lighting- restrooms/100 | $14,900 | 259 | - | - | $2,000 | 1.6 | 8.5 |
| 13 | EL6 | Convert to energy efficient motors | $17,200 | 284 | - | - | $2,200 | 1.5 | 8.9 |
| 14 | LT4A1 | Retrofit with T-8s & elect. ballasts - hallways/100 | $5,900 | 90 | - | - | $700 | 1.4 | 9.6 |
| 15 | BP7 | Install economizer | $104,100 | (82) | 3,691 | - | $9,300 | 1.4 | 12.5 |
| 16 | LT4A2 | Retrofit with T-8s & elect. ballasts - patient rooms/100 | $5,900 | 60 | - | - | $450 | 1.0 | 14.5 |
| 17 | HS7 | Install variable air volume controls | $329,600 | 2,472 | 1,880 | - | $23,900 | 0.9 | 15.4 |
| 18 | MI3D | Install occ. sensors to control lighting- exam rms/100 | $6,600 | 62 | - | - | $500 | 0.9 | 15.7 |
| 19 | KI8 | Install energy efficient kitchen exhaust hoods | $138,700 | (532) | 4,032 | - | $6,800 | 0.9 | 22.7 |
| 20 | KI5 | Install heat reclamation system for exhaust heat | $87,700 | (395) | 2,630 | - | $4,100 | 0.8 | 24.0 |
| 21 | EL3 | Increase power factor | $76,800 | - | - | - | $4,900 | 0.7 | 17.8 |
| 22 | LT4B1 | Replace MVs with T-8 fixtures | $830 | 4 | - | $9 | $42 | 0.6 | 22.3 |
| 23 | LT4A3 | Retrofit with T-8s & elect. ballasts - offices/100 | $5,900 | 27 | - | - | $200 | 0.4 | 32.1 |
| 24 | MI3C | Install occ. sensors to control lighting- offices/100 | $6,700 | 28 | - | - | $210 | 0.4 | 35.2 |
| 25 | BP16 | Install pony boiler | $100,600 | - | 517 | - | $1,400 | 0.2 | 80.7 |
| 26 | LT4B2 | Replace MVs with metal halides | $3,150 | 12 | - | ($80) | ($1,030) | 0.1 | 308.3 |
| 27 | BE2 | Install insulated glass or double-glazed windows | $242,000 | 2 | 62 | - | $200 | 0.0 | 999 |
| 28 | BP1 | Reduce steam distribution pressure from 60 to 30 psig | $25,800 | (2,413) | 3,432 | - | ($9,100) | 0.0 | 999 |
| 29 | BP8 | Install air heater | - | (82) | 3,691 | - | $9,300 | 0.0 | 999 |
| 30 | MI4 | Natural gas desiccant cooling | $176,900 | 833 | (2,804) | - | ($1,200) | -0.2 | 999 |

* Fuel oil

Table 4.1-4 ECO Evaluations Summary - Ordered by Payback

| No. | ECO ID | Description | Construction Cost | Annual Savings: Energy (MBtu/yr) Elec. | Annual Savings: Energy (MBtu/yr) NGas | Annual Savings: O&M | Annual Cost Savings | SIR | Simple Payback (yrs) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | HS24 | Surgical suite supply air reset | $1,400 | 738 | 1,984 | - | $11,000 | 108.0 | 0.1 |
| 2 | LT2 | Reduce lighting levels | $5,500 | 1,158 | - | - | $8,800 | 19.6 | 0.7 |
| 3 | HS18 | Reduce heated or cooled outside air | $1,100 | 136 | 32 | - | $1,100 | 12.7 | 1.1 |
| 4 | BP3 | Increase boiler efficiency (repair controls) | $24,000 | - | 6,706 | - | $18,100 | 11.6 | 1.5 |
| 5 | LT4C2 | Retrofit compact fluor's in lobby downlights. | $1,100 | 13 | - | $500 | $600 | 6.6 | 2.0 |
| 6 | MI3B | Install occ. sensors to control lighting-breakrooms. | $1,900 | 999 | - | - | $7,600 | 4.9 | 2.8 |
| 7 | BP17 | Install new unattended boilers | $427,800 | - | 8,971 | $120,000 | $144,200 | 4.1 | 3.3 |
| 8 | LT4C1 | Retrofit compact fluor's in restrooms. | $37,500 | 231 | - | $8,500 | $10,300 | 3.3 | 4.0 |
| 9 | EL4 | Use emergency generator to reduce demand | $182,400 | 15 | (416)* | $65,200 | $67,900 | 3.0 | 4.3 |
| 10 | BP15 | Install oxygen trim controls | $9,900 | - | 640 | - | $1,700 | 2.7 | 6.4 |
| 11 | HS13 | Use damper controls to shut off air to unoccupied areas | $111,500 | 2,041 | 1,505 | - | $19,600 | 2.3 | 6.4 |
| 12 | MI3A | Install occ. sensors to control lighting- restrooms/100 | $14,900 | 259 | - | - | $2,000 | 1.6 | 8.5 |
| 13 | EL6 | Convert to energy efficient motors | $17,200 | 284 | - | - | $2,200 | 1.5 | 8.9 |
| 14 | LT4A1 | Retrofit with T-8s & elect. ballasts - hallways/100 | $5,900 | 90 | - | - | $700 | 1.4 | 9.6 |
| 15 | BP7 | Install economizer | $104,100 | (82) | 3,691 | - | $9,300 | 1.4 | 12.5 |
| 16 | LT4A2 | Retrofit with T-8s & elect. ballasts - patient rooms/100 | $5,900 | 60 | - | - | $450 | 1.0 | 14.5 |
| 17 | HS7 | Install variable air volume controls | $329,600 | 2,472 | 1,880 | - | $23,900 | 0.9 | 15.4 |
| 18 | MI3D | Install occ. sensors to control lighting- exam rms/100 | $6,600 | 62 | - | - | $500 | 0.9 | 15.7 |
| 19 | EL3 | Increase power factor | $76,800 | - | - | - | $4,900 | 0.7 | 17.8 |
| 20 | LT4B1 | Replace MVs with T-8 fixtures | $830 | 4 | - | $9 | $42 | 0.6 | 22.3 |
| 21 | KI8 | Install energy efficient kitchen exhaust hoods | $138,700 | (532) | 4,032 | - | $6,800 | 0.9 | 22.7 |
| 22 | KI5 | Install heat reclamation system for exhaust heat | $87,700 | (395) | 2,630 | - | $4,100 | 0.8 | 24.0 |
| 23 | LT4A3 | Retrofit with T-8s & elect. ballasts - offices/100 | $5,900 | 27 | - | - | $200 | 0.4 | 32.1 |
| 24 | MI3C | Install occ. sensors to control lighting- offices/100 | $6,700 | 28 | - | - | $210 | 0.4 | 35.2 |
| 25 | BP16 | Install pony boiler | $100,600 | - | 517 | - | $1,400 | 0.2 | 80.7 |
| 26 | LT4B2 | Replace MVs with metal halides | $3,150 | 12 | - | ($80) | ($1,030) | 0.1 | 308.3 |
| 27 | BE2 | Install insulated glass or double-glazed windows | $242,000 | 2 | 62 | - | $200 | 0.0 | 999 |
| 28 | BP1 | Reduce steam distribution pressure from 60 to 30 psig | $25,800 | (2,413) | 3,432 | - | ($9,100) | 0.0 | 999 |
| 29 | BP8 | Install air heater | - | (82) | 3,691 | - | $9,300 | 0.0 | 999 |
| 30 | MI4 | Natural gas desiccant cooling | $176,900 | 833 | (2,804) | - | ($1,200) | -0.2 | 999 |

* Fuel oil

Table 4.1-5 Qualifying ECOs - Ordered by SIR

| No. | ECO ID | Description | Construction Cost | Annual Savings Energy (MBtu/yr) Elec. | NGas | O&M | Annual Cost Savings | SIR | Simple Payback (yrs) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | HS24 | Surgical suite supply air reset | $1,400 | 738 | 1,984 | - | $11,000 | 108.0 | 0.1 |
| 2 | LT2 | Reduce lighting levels | $5,500 | 1,158 | - | - | $8,800 | 19.6 | 0.7 |
| 3 | HS18 | Reduce heated or cooled outside air | $1,100 | 136 | 32 | - | $1,100 | 12.7 | 1.1 |
| 4 | BP3 | Increase boiler efficiency (repair controls) | $24,000 | - | 6,706 | - | $18,100 | 11.6 | 1.5 |
| 5 | LT4C2 | Retrofit compact fluor's in lobby downlights. | $1,100 | 13 | - | $500 | $600 | 6.6 | 2.0 |
| 6 | MI3B | Install occ. sensors to control lighting-breakrooms. | $1,900 | 999 | - | - | $7,600 | 4.9 | 2.8 |
| 7 | BP17 | Install new unattended boilers | $427,800 | - | 8,971 | $120,000 | $144,200 | 4.1 | 3.3 |
| 8 | LT4C1 | Retrofit compact fluor's in restrooms. | $37,500 | 231 | - | $8,500 | $10,300 | 3.3 | 4.0 |
| 9 | EL4 | Use emergency generator to reduce demand | $182,400 | 15 | (416)* | $65,200 | $67,900 | 3.0 | 4.3 |
| 10 | BP15 | Install oxygen trim controls | $9,900 | - | 640 | - | $1,700 | 2.7 | 6.4 |
| 11 | HS13 | Use damper controls to shut off air to unoccupied areas | $111,500 | 2,041 | 1,505 | - | $19,600 | 2.3 | 6.4 |
| 12 | MI3A | Install occ. sensors to control lighting- restrooms/100 | $14,900 | 259 | - | - | $2,000 | 1.6 | 8.5 |
| 13 | EL6 | Convert to energy efficient motors | $17,200 | 284 | - | - | $2,200 | 1.5 | 8.9 |
| 14 | LT4A1 | Retrofit with T-8s & elect. ballasts - hallways/100 | $5,900 | 90 | - | $0 | $700 | 1.4 | 9.6 |

* Fuel oil

Table 4.1-6 ECOs Not Qualifying - Ordered by SIR

| No. | ECO ID | Description | Construction Cost | Annual Savings Energy (MBtu/yr) Elec. | NGas | O&M | Annual Cost Savings | SIR | Simple Payback (yrs) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | BP7 | Install economizer | $104,100 | (82) | 3,691 | - | $9,300 | 1.4 | 12.5 |
| 2 | LT4A2 | Retrofit with T-8s & elect. ballasts - patient rms/100 | $5,900 | 60 | - | - | $450 | 1.0 | 14.5 |
| 3 | HS7 | Install variable air volume controls | $329,600 | 2,472 | 1,880 | - | $23,900 | 0.9 | 15.4 |
| 4 | MI3C | Install occ. sensors to control lighting- offices/100 | $6,600 | 62 | - | - | $500 | 0.9 | 15.7 |
| 5 | KI8 | Install energy efficient kitchen exhaust hoods | $138,700 | (532) | 4,032 | - | $6,800 | 0.9 | 22.7 |
| 6 | KI5 | Install heat reclamation system for exhaust heat | $87,700 | (395) | 2,630 | - | $4,100 | 0.8 | 24.0 |
| 7 | EL3 | Increase power factor | $76,800 | - | - | - | $4,900 | 0.7 | 17.8 |
| 8 | LT4B1 | Replace MVs with T-8 fixtures | $830 | 4 | - | $9 | $42 | 0.6 | 22.3 |
| 9 | LT4A3 | Retrofit with T-8s & elect. ballasts - offices/100 | $5,900 | 27 | - | - | $200 | 0.4 | 32.1 |
| 10 | MI3C | Install occ. sensors to control lighting- offices/100 | $6,700 | 28 | - | - | $210 | 0.4 | 35.2 |
| 11 | BP16 | Install pony boiler | $100,600 | - | 517 | - | $1,400 | 0.2 | 80.7 |
| 12 | LT4B2 | Replace MVs with metal halides | $3,150 | 12 | - | ($80) | ($1,030) | 0.1 | 308.3 |
| 13 | BE2 | Install insulated glass or double-glazed windows | $242,000 | 2 | 62 | - | $200 | 0.0 | 999 |
| 14 | BP1 | Reduce steam distribution pres. from 60 to 30 psig | $25,800 | (2,413) | 3,432 | - | ($9,100) | 0.0 | 999 |
| 15 | BP8 | Install air heater | - | (82) | 3,691 | - | $9,300 | 0.0 | 999 |
| 16 | MI4 | Natural gas desiccant cooling | $176,900 | 833 | (2,804) | - | ($1,200) | -0.2 | 999 |

**ECO #BE2 Install Double-Glazed Windows**

**Description**

All but 14 windows in the main building tower (sixth through thirteen floors) are single paned. This ECO examined the benefits of replacing these with double-pane windows.

**Analysis**

Eight floors (six through thirteen) are included in the analysis. There are 26 six foot by 4 foot windows per floor on the north and south exposures and four, five foot by four foot windows on the east and west exposures. All are single pane type except for 14 on the sixth floor north exposure.

**Results and Recommendations**

| | |
|---|---|
| Construction Costs | $242,000 |
| Annual Utility Savings Electricity (MBtu/Year) | 2 |
| Natural Gas Fuels (Mbtu/Year) | 62 |
| Annual Energy Cost Savings | $200 |
| Savings to Investment Ratio (SIR) | 0.0 |
| Simple Payback (Years) | 999 |

Based on the life cycle cost analysis, this project is not recommended.

**ECO #BE5 Install Vestibules on Entrances**

There are two high volume entrances to the hospital. One is the main entrance on the north side second floor and the other is the receiving area on the west side of the building third floor. The main entrance has a vestibule. The receiving entrance is not a good candidate for a vestibule due to wide variety of shapes, sizes and quantities of items brought into the hospital here. Therefore, no additional evaluation is necessary for this ECO.

**ECO #BP1 Reduce Boiler Pressure from 60 to 30 psig**

Currently, the boilers operate from 75 psig to 90 psig. Reducing the pressure to 60 psig requires no capital expense. Therefore, this action is discussed in Section 4.3, Operations and Maintenance Recommendations. ECO BP1 examines further reductions in pressure that do require substantial capital expenditure.

**Description**

The autoclaves require 743 lb/hr of steam if all 11 of them are operated simultaneously. They operate on approximately 60 (50-80) psig steam. This means that the entire steam production facility is forced to operate at a pressure above that required (30 psig) by the rest of the hospital. This ECO considers the possibility of supplying the autoclaves with a dedicated steam source at 60 psig. This would allow the rest of the system to glean the higher efficiency benefits of operating the boilers at the lower pressure of 30 psig.

**Analysis**

Detailed combustion calculations were run to determine the efficiency increase derived from operating the boiler at 30 psig. The energy associated with the autoclaves was calculated and then subtracted from the total gas energy supplied. The difference represents the gas energy needed by the rest of the hospital. The autoclave energy requirement is supplied through a dedicated electric boiler located in the hospital and connected directly to the existing 60 psig autoclave supply line, 150 degrees F condensate is returned. The efficiency of an electric boiler is very high (>95 percent) because nearly all of the energy goes into heating the water. The capital cost of an electric boiler installation large enough to supply all of the autoclaves simultaneously was estimated.

**Results and Recommendation**

| | |
|---|---|
| Construction Costs | $25,800 |
| Annual Utility Savings | |
| Electricity (MBtu/Year) | (2,413) |
| Natural Gas (MBtu/Year) | 3,432 |
| Annual Energy Cost Savings | ($9,100) |
| Annual O&M Cost Savings | $0 |
| Savings To Investment Ratio (SIR) | 0.0 |
| Simple Payback (Years) | 999 |

Based on the above life cycle cost analysis, this ECO is not recommended. The small increase in boiler efficiency is not enough to compensate for the high cost of electricity relative to natural gas.

**ECO #BP3 Increase Boiler Combustion Efficiency (Repair Boiler Fuel/Air Controls)**

Between the Interim and Prefinal Submittals, it was decided to expand the Renovation Project to include new boilers and controls. This ECO remains here for information only.

**Description**

In a combustion process, the proper adjustment of combustion air is the most important factor in maximizing efficiency. Maintaining the lowest possible residual $O_2$ in the stack gas concentration consistent with safe operating practices will provide the maximum combustion efficiency. Proper adjustment of stack gas $O_2$ involves making adjustments to the quantity of air supplied as well as the turbulence provided to mix the air and fuel. This ECO addresses the restoration of two existing control loops - $O_2$ stack gas recording and fuel/air ratio adjustment.

There are also problems with instability in the boiler control system. The drum level is nearly out of control on one boiler (No.3). The entire system seems to be under-damped. Recorder charts indicate this problem has existed for all of 1995 and perhaps longer. Recorder charts further indicate that the units are taking a 40 percent plus load swing in less than 15 minutes followed by a 40 percent load reduction in 15 minutes. The existing control loops should be able to efficiently control the boiler if tuned properly. These control loops include furnace draft, drum water level, fuel flow, air flow and fuel/air ratio. This ECO also includes the costs of repairing these controls.

**Analysis**

The burners at Fort Gordon are equipped with a spinner vane that must be positioned manually. The purpose for the spinner vane is to introduce turbulence to the incoming air so the air will more thoroughly mix with the fuel thereby increasing the probability of fuel and $O_2$ contacting each other. Adjusting the spinner vane should be done only at full load. The proper setting for the spinner vane is in the most closed position (most turbulence) which produces the lowest safe residual $O_2$ concentration in the stack gases. With the spinner vane inducing the most pressure drop and the most turbulence, the FD fan inlet vanes will be at or near their wide open position.

The practice at Fort Gordon is to adjust the residual stack $O_2$ to six percent. During one of the surveys, $O_2$ concentrations varied from 2.1 percent to 14 percent. Furthermore, the technique used for making the fine adjustments in the air is to adjust the furnace pressure using the ID fan control loop. This is wrong! The ID fan control loop controls only the furnace pressure. The FD fan inlet vanes should be adjusted to produce the proper amount of residual Stack $O_2$.

All three boilers are equipped with stack $O_2$ measurement equipment that record in the control room. Unfortunately, all three are in a state of disrepair and none record properly. Furthermore, all three boilers are equipped with a fuel-air ratio adjustment in the control room for each boiler; these appear to be nonfunctional too. If both the $O_2$ recorders and the adjustment for the fuel air ratio were restored to proper operational status, the control room operator could adjust the stack residual $O_2$ from the control room. The stack excess $O_2$ should be maintained at about 2.0 percent.

**Results and Recommendations**

| | |
|---|---|
| Construction Costs | $24,000 |
| Annual Utility Savings | |
| Electricity (MBtu/Year) | 0 |
| Natural Gas (MBtu/Year) | 6,706 |
| Annual Energy Cost Savings | $18,100 |
| Annual O&M Cost Savings | $0 |
| Savings To Investment Ratio (SIR) | 11.6 |
| Simple Payback (Years) | 1.5 |

Since new boilers are being funded as part of the Renovation Project, this ECO is not recommended.

Additionally, the feedwater control valve design should be reviewed to determine if it is contributing to the drum level control problems. The valve appears to be a quick opening valve design. An equal percentage valve design would be more forgiving and provide better control precision, particularly at lower loads.

### ECO #BP4 Repair Condensate Return System

The condensate return system is working satisfactorily. However, boiler water make-up is quite high, averaging 12 percent. See Section 4.3 for a discussion on Reduce Boiler Water Make-Up.

### ECO #BP6 Repair and Maintain Steam Lines and Traps

With the exception of one major steam leak on a main steam line flange of Boiler #3, the steam lines and traps were generally in good condition. No obvious waste was observed in either the hospital or the steam plant. The condensate storage tank temperature during a January visit was 150 degrees F indicating that quantity of steam bypassing traps was very low.

## ECO #BP7 Install Economizer

### Description

The existing boiler economizers and ID fans are scheduled for removal as part of the major project funded for FY96. The current installation has gas-side flow problems likely causing cold end corrosion. This ECO looks at the cost effectiveness of installing new economizers. Additional heat exchanging surface will be inserted into the hot exit gas stream leaving the boiler to reduce the exit gas temperature and increase boiler efficiency. An ID fan will be necessary to provide for the additional pressure drop accompanying the added surface.

### Analysis

Stack losses represent the largest heat loss from a boiler. The lower limit of stack temperature is a function of the boiler pressure and the feedwater temperature. Both are determined when the boiler is designed. If the boiler is to have the feedwater admitted directly to the drum then the manufacturer will install sufficient convective surface to lower the exit gas temperature to an economically competitive level. If too much surface is installed, the boiler price will be high, the exit gas temperature will be low and external tube corrosion may reduce tube life. If too little is installed, the boiler will be less expensive, but the exit gas temperature will be too high and valuable energy will be lost up the stack. There is, therefore, a balance between capital cost and operating cost which is designed into the boiler.

### Results and Recommendation

| | |
|---|---|
| Construction Costs | $104,100 |
| Annual Utility Savings | |
| Electricity (MBtu/Year) | (82) |
| Natural Gas (MBtu/Year) | 3,691 |
| Annual Energy Cost Savings | $9,300 |
| Annual O&M Cost Savings | |
| Savings To Investment Ratio (SIR) | 1.4 |
| Simple Payback (Years) | 12.5 |

The installation of economizers is not recommended on these boilers. The payback is too long and the risk of low load cold end corrosion is too great. Perhaps this is why the existing economizers are scheduled for removal due to excessive leaks and are currently bypassed.

## ECO #BP8 Install Air Heater

**Description**

Additional heat exchanging surface (air heater) will be inserted into the hot exit gas stream leaving the boiler to reduce the exit gas temperature and increase combustion air temperature. A new FD fan will be necessary to provide for the additional pressure drop accompanying the added surface.

**Analysis**

Stack losses represent the largest heat loss from a boiler. The lower limit of stack temperature is a function of the boiler pressure and the ambient air temperature. Both are determined when the boiler is designed. The manufacturer will install sufficient convective surface to lower the exit gas temperature to an economically competitive level. If too much surface is installed, the boiler price will be high, the exit gas temperature will be low and external tube corrosion may reduce tube life. If too little is installed the boiler will be less expensive, but the exit gas temperature will be too high causing valuable energy to be lost up the stack. There is, therefore, a balance between capital cost and operating cost which is designed into the boiler.

.**Results and Recommendation**

| | |
|---|---|
| Construction Costs | - |
| Annual Utility Savings | |
| Electricity (MBtu/Year) | 0 |
| Heating Fuels (MBtu/Year) | 3,691 |
| Annual Energy Cost Savings | $9,300 |
| Annual O&M Cost Savings | 0 |
| Savings To Investment Ratio (SIR) | - |
| Simple Payback (Years) | - |

The natural gas energy savings for this ECO is identical to ECO-BP7 because the exit gas temperature drop is the same. Since the specific volume of air is many times larger than water, the surface area required for this heat exchanger will be large compared to the economizer surface area in ECO-BP7. Because the air heater is much larger than the economizer and it must be custom made, it will be much more expensive than the economizer, yielding a longer payback.

Based on the results of the life cycle analysis, this ECO is not recommended.

## ECO #BP10 Clean Boiler Tubes

The boiler tubes were reportedly visually inspected during boiler shut downs in 1995. They are reported to be free of scale and in good condition. The boiler water chemical reports and practices support this observation. The pH is very high and the residual $Ca^{+}$ is <1 ppm indicating a low scaling potential.

There is no need to clean the internal surfaces of the boilers at this time. The boilers should be shut down once per year and internally inspected for tube scale, pitting, corrosion and general internal pressure part condition. If boiler water treatment is kept under control, scaling will not become a problem.

## ECO #BP11 Install Blowdown Controls

**Description**

Blowdown controls are used to automatically adjust the quantity of continuous blowdown. A correlation is made between boiler water conductivity and total suspended solids (TS) using boiler water samples. A conductivity probe measures the boiler water conductivity and opens a small blowdown valve on the steam drum when the conductivity gets too high thereby keeping the TS at or below a desired level.

**Analysis**

The total solids in these boilers is very low due to the relatively high bottom blowdown rate and the high level of condensate return. Bottom blowdown must continue to assure removal of undesirable accumulations from the lower drum. Since the TS is well below the recommended level of 3500 ppm and the TS can be easily controlled with the required bottom blows, there is no reason to install automatic blowdown controls at this time or for the foreseeable future.

**Recommendation**

Do not install blowdown controls at this time.

## ECO #BP14 Blowdown Heat Recovery

### Description

Blowdown heat recovery is a process of transferring the heat from blowdown water to make-up water. Blowdown heat recovery systems are typically found on large, high pressure boilers where both continuous blowdown and continuous make-up is required.

### Analysis

In Building 310, there is no continuous blowdown from any of the three boilers. Boiler blowdown is conducted daily from the lower drum of an operating boiler for about ten seconds duration. The make-up water flows intermittently only when the level in the condensate receiver tank is low. There is no assurance that the make-up water will be flowing when the boiler is being blown down.

### Recommendation

Because the blowdown flow is small, and because the make-up flow is intermittent, a blowdown heat recovery system is not recommended for this facility.

## ECO #BP15 Install $O_2$ Trim Controls

**Description**

Reportedly, the boilers are currently equipped with $O_2$ trim equipment. Unfortunately, it is in disrepair and it has been "disconnected" by order of "upper management". This ECO addresses the feasibility of repairing the existing $O_2$ sensors and recorders and installing a new controller on each boiler.

**Analysis**

Traditional fuel-air controls are adjusted to provide appropriate fuel-air mixtures over the load range of the unit. Typically, with good controls, $O_2$ can be safely reduced to 2.0 percent over the load range with little difficulty. However, without $O_2$ trim controls, the control system cannot respond to a number of process variables that will effect efficiency. Some of these variables are:

- Changes in barometric pressure and temperature which affect FD fan performance.
- Changes in fuel gas composition which will affect the air required for combustion. In the winter, gas companies sometimes augment natural gas supplies with other gaseous fuels such as propane. This will cause a rise in the stack gas $O_2$ since it takes nine percent less air to burn propane than methane. Conversely, when the augmentation ceases, more air will be required to maintain desired $O_2$ levels.
- Changes in boiler gas-side pressure drop affect FD fan performance on a pressurized furnace design. Recall that the Fort Gordon boilers will revert to the original pressurized furnace design when the ID fans are removed in 1996.
- Variations in operator opinion regarding flame appearance.

$O_2$ trim controls are specifically designed to compensate for these variables. The $O_2$ trim system components consist of a stack $O_2$ probe(s) and controls to slowly adjust the fuel-air ratio to maintain the desired $O_2$. $O_2$ trim controls can not cure the ills of a poorly operating control system. The existing controls must be repaired or replaced first.

**Results and Recommendation**

| | |
|---|---|
| Construction Costs | $9,900 |
| Annual Utility Savings | |
| Electricity (MBtu/Year) | 0 |
| Heating Fuels (MBtu/Year) | 640 |
| Annual Energy Cost Savings | $1,700 |
| Annual O&M Cost Savings | $0 |
| Savings To Investment Ratio (SIR) | 2.7 |
| Simple Payback (Years) | 6.4 |

Since new boilers and controls will be added as part of the Renovation Project, this ECO is not recommended.

**ECO #BP16 Install Pony Boiler**

**Description**

When there is a wide difference in seasonal steam demand it sometimes makes sense to install a "small" boiler capable of handling the off season steam demand rather than operating large boilers at very low loads. The "Pony" boiler becomes quite attractive if it can be operated unattended when compared to larger boilers which need attention around the clock.

The pony boiler would operate in parallel with the existing boilers in the existing steam plant using the existing auxiliaries (feedwater, condensate return, fuel, etc.)

**Analysis**

Energy consumption records indicate the hospital summer steam demand decreases to about 33 percent of its winter demand. The existing steam plant can comfortably operate at 33 percent of the winter demand. Combustion efficiency can be maintained at 78 percent with little or no additional operational effort.

A pony boiler with a capacity of up to ten MBtu/hr would be required. This can hardly be called a "Pony" boiler with a capacity of 33 percent of full load. A modern fire tube boiler operating at 60 psig can consistently attain a combustion efficiency of 82 percent. There is no substantial savings in O&M since the other equipment in the building will have to be attended anyway.

**Results and Recommendations**

| | |
|---|---|
| Construction Cost | $100,600 |
| Annual Utility savings | |
| Electricity (MBtu/Year) | 0 |
| Natural Gas (MBtu/Year) | 517 |
| Annual Energy Cost Savings | $1,400 |
| Annual O&M cost savings | $0 |
| Savings to Investment Ratio (SIR) | 0.2 |
| Simple Payback (years) | 80.7 |

Based on the above life cycle cost analysis, this ECO is not recommended.

**ECO #BP17 Install New Unattended Boilers**

**Description**

The existing boilers require round the clock attendance due to their age and degree of automation. Three 15,000 lb/hr fire tube boilers will be installed. The old boilers will be removed and sold. The new boilers will require only intermittent attention. Existing fuel and water systems will be reused.

**Analysis**

The new boilers will require only occasional attention, similar to the other boilers on post. The savings will come from the elimination of the operator positions. Currently, the existing boilers are continuously attended by at least one operator per shift. A total of four positions would be eliminated.

**Results and Recommendations**

| | |
|---|---|
| Construction Cost | $427,800 |
| Annual Utility savings | |
| Electricity (MBtu/Year) | 0 |
| Natural Gas (MBtu/Year) | 8,964 |
| Annual Energy Cost Savings | $24,200 |
| Annual O&M Cost Savings | $120,000 |
| Savings to Investment Ratio (SIR) | 4.1 |
| Simple Payback (years) | 3.3 |

Based on the above life cycle cost analysis, this ECO qualifies for funding. However, since new boilers have become part of the FY 96 Renovation Project, it is not included in the list of recommended ECOs.

**ECO #EL3 Install Capacitors to Increase Power Factor**

**Description**

Power factor is a measure of the electrical efficiency of a distribution system. It is the ratio of the productive, or real power, to the total power required by the load. Real power is measured in kilowatts (kW) and is the power a load consumes. Apparent power is measured in kilovolt amperes (kVA) and is the power supplied to serve the kW load. The power factor (PF) can be described by the following relationship.

$$PF = kW / kVA$$

Low PF is primarily due to lagging current used to magnetize fields in various equipment and the circuits supplying them. Induction motors, transformers, and solenoids draw excitation currents to develop magnetic fields to allow operation of their respective devices.

The result of low PF is decreased voltages and increased $I^2R$ losses. This causes:

1. Decreased lighting output.
2. Decreased temperatures in heating devices.
3. Decreased speed of induction motors.
4. Increased conductor temperatures.
5. Decreased capacity of contacts, circuits, circuit breakers, fuses, transformers and generating equipment.

**Analysis**

Electric utilities are also affected by low PF of customers and have established additional charges for these. Georgia Power Company, the local electricity utility, charges $0.27/reactive kVA/month for all reactive kVA causing a PF less than 0.95. The EAMC power factor averages about 0.80 and, as a result, incurs annual charges of about $6,000 for low PF.

**Results and Recommendations**

| | |
|---|---|
| Construction Cost | $78,600 |
| Annual Utility savings | |
| Electricity (MBtu/Year) | 0 |
| Natural Gas (MBtu/Year) | 0 |
| Annual Energy Cost Savings | $0 |
| Annual O&M Cost Savings | - |
| Annual Cost Savings | $4,900 |
| Savings to Investment Ratio (SIR) | 0.7 |
| Simple Payback (years) | 17.8 |

·Based on the above life cycle cost analysis, this ECO is not recommended.

**ECO #EL4 Use Emergency Generator to Reduce Peak Demand**

**Description**

The hospital currently uses two generators to reduce the electrical demand when requested by the local utility, Georgia Power and Light. One is 800 kW and the other is 2,100 kW. To meet the requirements of the Supplemental Energy (SE) rider, the hospital must reduce its demand below 2,960 kW during curtailment hours. The EAMC peak is about 4,200 kW. Even though the 2,100 kW generator cannot be fully loaded, the two generators easily meet the maximum reduction request (which is a maximum of 1,300 kW [4,200 - 2,960]). If the 2,100 kW generator was paralleled with utility grid, it could be fully utilized. Under the existing rate, the demand charge is only $0.80/kW for four months of the year and this would be of little benefit. However, the EAMC could apply for additional credits using the Interruptible Service (IS) rider.

**Analysis**

The IS rider credits the customer $45/kW annually for the contract amount. The EAMC would be required to reduce their demand by that amount. Using both generators (a total of 2,900 kW), the EAMC could reduce their demand 1,660 kW below their current billing demand. If the EAMC contracted for 1,500 kW, this would be worth $67,500 each year.

IS customers are called after SE and have only been called once in the eight plus years it has been offered. This occurred in 1995, required a total of 20 hours and overlapped SE calls except for one-half hour. Also, four hours of missed curtailments are allowed each year.

**Results and Recommendations**

| | |
|---|---|
| Construction Cost | $182,400 |
| Annual Utility savings | |
| Electricity (MBtu/Year) | 15 |
| Fuel Oil (MBtu/Year) | (416) |
| Annual Energy Cost Savings | $2,700 |
| Annual O&M Cost Savings | $65,200 |
| Annual Cost Savings | $67,900 |
| Savings to Investment Ratio (SIR) | 3.0 |
| Simple Payback (years) | 4.3 |

Based on the above life cycle cost analysis, this ECO is recommended.

**ECO #EL6 Convert to Energy-Efficient Motors**

**Description**

This project consists of replacing 29 existing standard-efficiency electric motors with high-efficiency electric motors. Supply, return, and exhaust fan motors are the primary candidates for replacement since they are not scheduled for removal during the FY96 Renovation Project.

**Analysis**

High-efficiency electric motors can save significant amounts of energy over standard efficiency types. It is always cost effective to replace failed standard efficiency motors with high efficiency units. Care should be taken when replacing standard motors with high-efficiency types because of their different operating speeds. High-efficiency motors typically operate about 1.5 percent faster than corresponding standard types. The result is a five-percent increase in load on the motor. The increased speed can be easily adjusted on AHUs, but not on pumps and other direct-coupled devices.

Energy savings were calculated using operating conditions for current operating hours and for projected operating hours, which will be implemented after Renovation Project improvements have been made. The energy savings calculations using the projected reduced operating hours are more conservative and are therefore tabulated in the Results and Recommendations section.

**Results and Recommendations**

| | |
|---|---|
| Construction Costs | $17,200 |
| Annual Utility Savings | |
| Electricity (MBtu/Year) | 284 |
| Natural Gas (MBtu/Year) | 0 |
| Annual Energy Cost Savings | $2,200 |
| Annual O&M Cost Savings | 0 |
| Savings to Investment Ratio (SIR) | 1.5 |
| Simple Payback (Years) | 8.9 |

Based on the life cycle cost analysis, this project is recommended. Even though the electric rate is low, since most of these motors operate continuously, replacement of motors from five to 75 horsepower results in simple paybacks which are less than ten years.

**ECO #HS3 Use Energy Recovery Units**

**Description**

Approximately 68,000 cfm of 75 degree F air is currently being exhausted from the areas served by AHU-4E and AHU-4W. This project consists of installing coils in the outside air streams and exhaust air ducts, a circulating pump, piping, ductwork and controls. This is a "run-around" loop that would precool the outside air during the summer and preheat the outside air during the winter.

**Analysis**

AHU-4E and AHU-4W are located on the fourteenth floor and serve the fourth floor through the thirteenth floors. This is a constant volume, terminal reheat system. The supply air temperature is maintained at 57 degrees F year round for humidity control. The outside air economizers are not currently functioning properly, however, they are scheduled to be repaired/replaced as part of the funded Renovation Project.

Exhaust air energy recovery will save cooling energy when the outside air temperature is above the exhaust air temperature and will save heating energy when the mixed air temperature is below the required supply air temperature (~57 degrees F). Calculations show the outside air temperature must be lower than seven degrees F before heating is required.

Augusta, Georgia bin temperature data indicate that the winter temperatures rarely go below ten degrees F, therefore, there will be minimal heating savings for this project.

Cooling energy savings were calculated based on bin temperature data. The energy recovery coils will add about one inch of static pressure to the supply and exhaust systems, which will increase the fan motor energy consumption.

**Results and Recommendations**

The cooling energy savings were less than the increase in fan motor energy use which results in a net increase in energy consumption and cost. This project was not analyzed further and is not recommended.

**ECO# HS7 Install Variable Air Volume Controls**

**Description**

This project consists of installing variable frequency drives (VFDs) and static pressure controls for the supply and return fan motors, and replacing the existing terminal reheat boxes with new variable air volume (VAV) boxes with hot water reheat coils. This ECO involves the fourth floor only and its associated AHUs and return fans.

**Analysis**

The entire fourth floor and some areas of the third floor contain administrative offices. These areas are typically not occupied at night. Supply air to these areas can be reduced to the minimum outside air requirement during occupied times and shut off during non-occupied periods. Energy savings can be achieved by modulating the supply air volume to administrative areas when the cooling and heating loads are lower than the peak design loads.

AHU-4E and AHU-4W serve the fourth through the thirteenth floors of the hospital. Calculations based on the design air flow rates indicate that approximately 20 percent of the supply air and return air for AHU-4E and AHU-4W is utilized by the fourth floor.

The VFDs would be installed on the two 125 horsepower supply air fan motors (SF-4A and SF-4B) and the two 30 horsepower return air fan motors (RF-2A and RF-2B). Static pressure controls will be installed to vary the fan speed and maintain system pressure. There are 63 terminal reheat boxes of various sizes on the fourth floor. These boxes will be removed and replaced with new VAV boxes that include hot water reheat coils. New controls for this project will be the direct digital (DDC) type.

Fan motor energy savings will be realized by operating the motors at about 80 percent of full load (no air supplied to the fourth floor) during unoccupied hours and modulating between 90 percent and 100 percent of full load (50 percent to 100 percent of air supplied to the fourth floor) during occupied times.

**Results and Recommendations**

| | |
|---|---|
| Construction Costs | $329,600 |
| Annual Utility Savings (Increase) | |
| Electricity (MBtu/Year) | 2,472 |
| Natural Gas (MBtu/Year) | 1,880 |
| Annual Energy Cost Savings (Increase) | $23,900 |
| Annual O&M Cost Savings (Increase) | 0 |
| Savings to Investment Ratio (SIR) | 0.9 |
| Simple Payback (Years) | 15.4 |

The above analysis and results are converting the fourth floor from constant volume air flow to a VAV system. Based on the life cycle cost analysis, this project is not recommended.

Converting the first, second or third floor administrative areas to VAV would require the same procedure and produce similar life cycle cost results. Therefore, converting the other floor administrative areas to VAV is not recommended.

**ECO #HS11 Replace Oversized Motors**

The Renovation Project replaced the following motors:

- Boiler feed water pumps (4)
- Condensate transfer pumps (2)
- Primary chilled water pumps (3)
- Secondary chilled water pumps (3)
- Cooing tower fans (3)
- Condenser water pumps

The only remaining large motors are supply and exhaust fans. All fans have been adjusted to maximize the motor loads.

**ECO #HS13 Use Damper Controls to Shut Off Air to Unoccupied Areas**

**Description**

This project consists of installing variable frequency drives on fan motors; motorized dampers in the supply, return and exhaust ductwork; and associated controls for the fourth floor branches of AHU-4E and AHU-4W.

**Analysis**

The fourth floor of the hospital is primarily administrative offices which are only occupied during regular business hours. By using damper controls to shut off air to this area at night, significant energy and cost savings can be realized. Variable frequency drives (VFDs) are installed on two 125-hp supply fan motors, two 30-hp return air fan motors, one 7.5-hp exhaust fan motor and one five-hp exhaust fan motors. The VFDs have isolating transformers to protect the motors from power surges and spikes. Motorized dampers in the fourth floor branch ductwork and controls are included as part of this project. The damper control system will reset the VFDs to maintain required air flows on the fifth through fourteenth floors of the hospital. This can be done in the following manner. Measure total AHU airflow and airflow to the fourth floor with the fourth floor dampers open. Close fourth floor dampers and manually adjust the AHU VFD until the total flow is equal to the flow with the damper open less the fourth floor airflow (with damper open). Record this setting and use controls to reset the VFD to this position when dampers are closed.

**Results and Recommendations**

| | |
|---|---|
| Construction Costs | $111,500 |
| Annual Utility Savings (Increase) | |
| Electricity (MBtu/Year) | 2,041 |
| Natural Gas (MBtu/Year) | 1,505 |
| Annual Energy Cost Savings (Increase) | $19,600 |
| Annual O&M Cost Savings | 0 |
| Savings to Investment Ratio (SIR) | 2.3 |
| Simple Payback (Years) | 6.4 |

Based on the life cycle cost analysis, this project is recommended. It is not feasible to damper other administrative areas in the hospital. The first three floors have a common return. Modulating flows of these three AHUs would be extremely complicated. On other floors, administrative areas are too scattered to make dampering feasible.

**ECO #HS16 Reduce AHU Air Volumes**

**Description and Analysis**

A simplified analysis of supply flow rates is summarized in Table 2.2-3. All AHUs are delivering considerably more (up to almost 40 percent) than minimum design requirements. In discussions with EAMC staff, these adjustments have been made to relieve undercooling problems. Therefore, reductions are not recommended.

## ECO #HS18 Reduce Heated or Cooled Outside Air

### Description

This ECO addresses the energy savings that can be achieved by reducing outside air (OSA) flows to design requirements for AHU-4E and AHU-4W.

### Analysis

Table 2.1-3 compares design, measured and required outside air volumes for the hospital. Four AHUs--4E, 4W, 5 and 6–show considerably more OSA than is required by Army standards. Two AHUs (5 and 6) are 100 percent OSA units and cannot be reduced without coincidently reducing cooling capacity. However, AHUs 4E and 4W can be reduced from 29 percent and 37 percent, respectively to 22.5 percent and 23.6 percent.

The reduction in outside air amounts should be done during the FY96 Renovation Project. Part of this project is to replace outside and return air inlet dampers and actuators. A test and balance must be done at this time to set the minimum outside air damper position.

### Results and Recommendations

| | |
|---|---|
| Construction Costs | $1,100 |
| Annual Utility Savings | |
| Electricity (MBtu/Year) | 136 |
| Natural Gas (MBtu/Year) | 32 |
| Annual Energy Cost Savings | $1,100 |
| Savings to Investment Ratio (SIR) | 12.7 |
| Simple Payback (Years) | 1.1 |

Based on the life cycle cost analysis, this project is recommended.

**ECO #HS24 Setback Supply and Exhaust Air for the Surgical Suite**

**Description**

This project utilizes the variable frequency drives (VFDs) and direct digital controls DDC installed with the funded renovations. The new DDC system will be programmed to setback the supply and exhaust fans during periods when the area is unoccupied. Manual override controls (hand/off/auto switch) will be installed in the Supervising Surgical Nurse's Station. This ECO will allow the supply and exhaust fans for the surgical suite to operate at reduced power at night and on weekends.

**Analysis**

The surgical suite is located on the third floor and includes the surgical intensive care unit, post anesthesia recovery ward, doctors lounge area and the operating rooms. These areas are typically not occupied at night or during weekends. Current supply air flow to the surgical suite provides approximately 8.25 air changes per hour. Supply air to these areas can be reduced to three air changes per hour during unoccupied times according to MIL-HDBK-1191, Military Handbook, DoD Medical and Dental Treatment Facilities, Design and Construction Criteria, October 15, 1991. Energy savings can be achieved by modulating the supply air volume to administrative areas when the cooling and heating loads are lower than the peak design loads.

Conditioned outside air is supplied to the surgical suite by SF-6 and exhausted by EF-6. The funded Renovation Project includes installing VFDs on the 40 horsepower motor for SF-6 and the five horsepower motor for EF-6. DDC hardware and software for day/night setback, speed control, start/stop, alarm status and power monitoring is also being installed.

A setback schedule and minimum flow rates for the supply and exhaust fans will be programmed into the DDC control system. The design positive pressure for the surgical suite is about 18 percent of the supply air flow. The minimum supply and exhaust flows will be set to maintain the same positive pressure during unoccupied times. The fans will be able to operate at full capacity during occupied times to maintain the required space conditions.

The project costs include labor for engineering, calibration, start-up and checkout for each control point. Fan motor energy savings will be achieved by operating the supply and exhaust fan motors at about 40 percent of full capacity during unoccupied hours. Calculations for fan motor energy savings are contained in the appendix.

**Results and Recommendations**

| | |
|---|---|
| Construction Costs | $1,400 |
| Annual Utility Savings (Increase) | |
| Electricity (MBtu/Year) | 738 |
| Natural Gas (MBtu/Year) | 1,984 |
| Annual Energy Cost Savings (Increase) | $11,000 |
| Annual O&M Cost Savings (Increase) | 0 |
| Savings to Investment Ratio (SIR) | 108.0 |
| Simple Payback (Years) | 0.1 |

Based on the life cycle cost analysis, this project is recommended.

**ECO #KI5 Heat Reclaim System for Kitchen Exhaust Heat**

**Description**

This project consists of installing some new duct work and a heat pipe energy recovery system for the heating and ventilating system that serves the kitchen.

**Analysis**

During the winter time the kitchen make-up air unit (MAU) utilizes a steam heating coil to heat 100 percent outside air and then supplies the heated air to the range hoods and other areas of the kitchen. The heated make-up air is then exhausted by EF-7, an exhaust system with grease collection. The efficiency of the kitchen ventilation system can be improved by recovering waste heat from the exhaust air and using it to preheat the make-up air. The MAU and EF-7 are located in the same room, just west of the kitchen area.

A heat pipe air-to-air heat exchanger will be used recover heat from the approximately 90°F exhaust air and preheat the cold outside air before it gets to the steam heating coil. A heat pipe heat exchanger is a bank of horizontal sealed tubes with refrigerant inside. When one side of the tubes is heated by the exhaust air, the refrigerant absorbs the heat and vaporizes. The refrigerant vapor then condenses on the other side which releases the heat to the cold outside air. Energy recovery efficiencies are typically about 60 percent for heat pipe heat exchangers. Another benefit of heat pipes is that no pumps and associated controls are required with this type of heat exchanger and the two air streams do not mix.

Installing the heat recovery coil will increase the static pressure requirements for both the MAU fan and the exhaust fan. The existing 20 horsepower fan motor for the MAU will have to be replaced with a new 40 horsepower motor. EF-7 has a 100 horsepower motor which is large enough to handle the new pressure. The increased static pressure will also increase the fan energy consumption by both motors. The increase in electricity use will be for the entire year, not just the heating season.

Heating energy savings are obtained by reducing the amount of steam heating required during winter time operation. The savings were calculated based on the bin temperature data for August, GA, and assuming heating will only be required when the outside air temperature is below 55 degrees F.

**Results and Recommendations**

| | |
|---|---|
| Construction Costs | $87,700 |
| Annual Utility Savings (Increase) | |
| Electricity (MBtu/Year) | (395) |
| Natural Gas (MBtu/Year) | 2,630 |
| Annual Energy Cost Savings (Increase) | $4,100 |
| Annual O&M Cost Savings (Increase) | 0 |
| Savings to Investment Ratio (SIR) | 0.8 |
| Simple Payback (Years) | 24.0 |

Based on the results of the above life cycle cost analysis, this ECO is not recommended.

## ECO #KI8 Energy Efficient Kitchen Exhaust Hoods

### Description

This project consists of removing the five of the existing kitchen range exhaust hoods and installing new energy efficient exhaust hoods.

### Analysis

During the winter time, the kitchen make-up air unit (MAU) utilizes a steam heating coil to heat 100 percent outside air and then supplies the heated air to the range exhaust hoods and other areas of the kitchen. The heated make-up air is then exhausted by EF-7. The heating energy use of the kitchen ventilation system can be reduced by utilizing energy efficient exhaust hoods. This type of hood can be supplied with unheated make-up air. The total makeup air for the five exhaust hoods to be replaced is 28,600 cubic feet per minute (cfm).

There are two zones served by the MAU that still require heated supply air. The supply air to the two zones is 1,600 cfm and 4,200 cfm for a total of 5,800 cfm that must be heated. This project will include installing duct mounted electric heating coils and thermostat controls for these areas. The electric heating coils will increase the electricity used for heating during the winter. The increased static pressure requirements due to electric heating coils is typically very low. The life cycle cost analysis assures the increase in fan energy use will be negligible.

Heating energy savings are obtained by reducing the amount of steam heating required during winter time operation. The savings were calculated based on the bin temperature data for Augusta, Georgia and assuming heating will only be required when the outside air temperature is below 55 degrees F.

### Results and Recommendations

| | |
|---|---|
| Construction Costs | $138,680 |
| Annual Utility Savings (Increase) | |
| Electricity (MBtu/Year) | (532) |
| Natural Gas (MBtu/Year) | 4,032 |
| Annual Energy Cost Savings (Increase) | $6,800 |
| Annual O&M Cost Savings (Increase) | 0 |
| Savings to Investment Ratio (SIR) | 0.9 |
| Simple Payback (Years) | 22.7 |

Based on the results of the life cycle cost analysis, this ECO is not recommended.

**ECO #LT2 Reduce Lighting Levels**

**Description**

The ECO involves delamping fluorescent fixtures in over-lighted areas.

**Analysis**

Lighting levels were measured throughout the hospital. The results of these measurements are summarized in Table 2.1-2. Some overlighted areas were observed. These are the fourth floor library, the medical records area in the family practice wing, most hallways and several offices and examination rooms.

All overlighted areas, except for hallways, use four lamp fluorescent fixtures. Removing one lamp from each hallway fixture would reduce average light levels in hallways from 30 to 35 foot candles to 15 to 18 foot candles. The fixtures in the family practice records area are circuited so that half of the lamps in the four-lamp fixtures can be de-energized from the wall switch. The fixtures in the fourth floor library would have to be delamped and ballasts disconnected.

**Results and Recommendations**

| | |
|---|---|
| Construction Costs | $5,500 |
| Annual Utility Savings (Increase) | |
| Electricity (MBtu/Year) | 1,158 |
| Natural Gas (MBtu/Year) | - |
| Annual Energy Cost Savings | $8,800 |
| Savings to Investment Ratio (SIR) | 19.6 |
| Simple Payback (Years) | 0.7 |

Based on the life cycle cost analysis, this project is recommended.

**ECO #LT4 Convert to Energy Efficient Lighting Systems**

There are three primary types of lighting at the EAMC. These are fluorescents, necessary vapor and incandescents. Fluorescents are the most common and are used in most areas of the hospital. Mercury vapor lamps are found in high ceiling areas such as the cafeteria dining room, lobby areas, the third floor storage area and many fourth floor offices. Incandescents are generally found in restrooms, patient bathrooms and some lobby lighting on the fourth floor. Because of the wide variety of lighting, the evaluation will be divided into three parts, one for each type:

A - Fluorescents
B - Mercury Vapor
C - Incandescents

**ECO #LT4A T8 Lamps and Electronic Ballasts**

**Description**

This ECO involves direct one-for-one replacement of 40-watt, T-12 lamps and magnetic ballasts with 32-watt, T-8 lamps and electronic ballasts.

**Analysis**

There is an ongoing project at the EAMC to replace the existing T-12 (40 watt) fluorescent lamps and magnetic ballasts with T-8 (32 watt) lamps and electronic ballasts. The T8 system offers high efficiency values (~86 lumens per watt) when compared to the existing T12 systems (~65 lumens per watt).

The current FY96 Renovation Project replaces the existing two by four fixture with acrylic lens with a parabolic troffer. It would be very difficult to justify a complete fixture replacement with energy savings. This ECO evaluates replacement of lamps and ballasts only.

The analysis was performed for three different applications - hallways, offices an patient rooms. These applications represented three different hours of operation - 8760, 5800 and 2600, respectively. Calculations are performed on a 100 unit basis.

**Results and Recommendations**

| Per 100 Basis | LT4A1 Hallways | LT4A2 Patient Rooms | LT4A3 Offices |
|---|---|---|---|
| Construction Costs | $5,900 | $5,900 | $5,900 |
| Annual Utility Savings | | | |
| Electricity (MBtu/Year) | 90 | 60 | 27 |
| Natural Gas (MBtu/Year) | - | - | - |
| Annual Energy Cost Savings | $700 | $450 | $200 |
| Savings to Investment Ratio (SIR) | 1.4 | 1.0 | 0.4 |
| Simple Payback (Years) | 9.6 | 14.5 | 32.1 |

Based on the life cycle cost analysis, this project can only be recommended for hallway lighting or other fixtures that operate continuously.

**ECO #LT4B1 Replace Mercury Vapor Lamps in Office Areas with Fluorescent Fixtures**

**Description**

This ECO examines the replacement of 175-watt mercury vapor lamp fixtures with two by four fluorescent parabolic troffers with T8 lamps and electronic ballasts in fourth floor offices.

**Analysis**

Office areas on the fourth floor use mercury vapor lighting. Mercury vapor lamps have a low efficiency of about 43 lumens per watt for a 175-watt lamp. Only incandescents offer lower values. Replacing these fixtures with new parabolic fixtures with T8 lamps and electronic ballasts increase efficiency values to about 86 lumens per watt.

**Results and Recommendations**

| | |
|---|---|
| Construction Costs | $830 |
| Annual Utility Savings (Increase) | |
| Electricity (MBtu/Year) | 4 |
| Natural Gas (MBtu/Year) | - |
| Annual Energy Cost Savings (Increase) | $42 |
| Annual O&M Cost Savings (Increase) | $9.00 |
| Savings to Investment Ratio (SIR) | 0.6 |
| Simple Payback (Years) | 22.3 |

Based on the life cycle cost analysis, this project is not recommended.

## ECO #LT4B2 Replace Mercury Vapor Lamps in Office Areas with Metal Halide Lamps

### Description

In this ECO, 175-watt mercury vapor lamps and ballast fixtures are replaced with 100-watt metal halide lamps and ballast fixtures in fourth floor offices.

### Analysis

Office areas on the fourth floor use mercury vapor lighting. Mercury vapor lamps have a low efficiency of about 43 lumens per watt for a 175-watt lamp. Only incandescents offer lower values. Replacing these fixtures with metal halide lamps increases efficiency values to about 70 lumens per watt. A lumen method calculations shows that six metal halide fixtures will be needed to maintain the lighting levels above the required 50 foot candles.

### Results and Recommendations

| | |
|---|---|
| Construction Costs | $3,150 |
| Annual Utility Savings (Increase) | |
| Electricity (MBtu/Year) | 12 |
| Natural Gas (MBtu/Year) | - |
| Annual Energy Cost Savings (Increase) | ($1,030) |
| Annual O&M Cost Savings (Increase) | ($80) |
| Savings to Investment Ratio (SIR) | 0.1 |
| Simple Payback (Years) | 308.3 |

Based on the life cycle cost analysis, this project is not recommended.

**ECO #LT4C1 Compact Fluorescents in Restrooms**

**Description**

This ECO involves the one-for-one replacement of incandescent lamps with compact fluorescents in patient and other restroom areas.

**Analysis**

Most of the patient restrooms have incandescent fixtures. Compact fluorescents have incandescent fixtures. Compact fluorescents can be installed and improve the fixture efficiency from 15 lumens per watt to about 44 lumens per watt. Replace labor costs are also reduced since compact fluorescent lifetime is about 10,000 hours compared to 1,000 hours for an incandescent lamp.

**Results and Recommendations**

| | |
|---|---|
| Construction Costs | $37,500 |
| Annual Utility Savings (Increase) | |
| Electricity (MBtu/Year) | 231 |
| Natural Gas (MBtu/Year) | - |
| Annual Energy Cost Savings (Increase) | $1,800 |
| Annual O&M Cost Savings (Increase) | $8,500 |
| Savings to Investment Ratio (SIR) | 3.3 |
| Simple Payback (Years) | 4.0 |

Based on the life cycle cost analysis, this project is recommended.

**ECO #LT4C2 Compact Fluorescents in Lobby Area Downlights**

**Description**

In this ECO, 52-watt incandescents are replaced with 18-watt compact fluorescents in lobby area "high hat" fixtures.

**Analysis**

Incandescents are used for lighting in the south lobby of the fourth floor. Compact fluorescents offer increased efficiencies (44 lumens per watt, compared to 15 lumens per watt for incandescents) and increased lifetimes (10,000 hours versus 1,000 hours). This is particularly important in areas that are difficult to relamp such as high-ceiling lobbies.

**Results and Recommendations**

| | |
|---|---|
| Construction Costs | $1,100 |
| Annual Utility Savings (Increase) | |
| Electricity (MBtu/Year) | 13 |
| Natural Gas (MBtu/Year) | - |
| Annual Energy Cost Savings (Increase) | $100 |
| Annual O&M Cost Savings (Increase) | $500 |
| Savings to Investment Ratio (SIR) | 6.6 |
| Simple Payback (Years) | 2.0 |

Based on the life cycle cost analysis, this project is recommended.

**ECO #LT5 Install Reflectors in Fluorescent Fixtures**

Reflectors are used to increase the efficiency of lighting fixtures. They can reduce the amount of lamps or fixtures required to provide adequate lighting. The use of reflectors are evaluated when conventional fixtures do meet light level requirements and are not evaluated as a separate ECO.

**ECO# MI3 Install Occupancy Sensors for Lighting Control**

**Description**

This ECO addresses occupancy sensors for four applications:

- ECO #MI3A - Restrooms
- ECO #MI3B - Breakrooms
- ECO #MI3C - Offices
- ECO #MI3D - Examination Rooms

These devices can save energy by de-energizing lighting when intermittently used areas are not occupied.

**Analysis**

The cost effectiveness of occupancy sensors depends on how long can the lights be de-energized and how many watts of lighting are being turned off. Screening calculations were performed for all three applications with varying number of lighting fixtures.

**Results and Recommendations**

The results of the life cycle cost analysis are shown below. In summary, all restrooms with at least three, two-lamp, T-8 fluorescent fixtures or equivalent (~174 watts) on a single circuit will payback within ten years. In breakrooms, only two, two-lamp fixtures are needed (~116 watts) and even large offices with six, two-lamp fixtures have paybacks greater than ten years. The results below are presented for three, two-lamp fixtures (two for examination rooms) on a per 100 unit basis for all cases except breakrooms. Breakrooms were evaluated on actual lamp counts which are listed by rooms in the appendix.

| | Restrooms MI3A | Breakrooms MI3B | Offices MI3C | Exam Rooms MI3D |
|---|---|---|---|---|
| Construction Costs | $14,900 | $19,000 | $6,700 | $6,600 |
| Annual Utility Savings | | | | |
| Electricity (MBtu/Year) | 259 | 999 | 28 | 62 |
| Natural Gas (MBtu/Year) | - | - | - | - |
| Annual Energy Cost Savings | $2,000 | $7,600 | $210 | $500 |
| Savings to Investment Ratio (SIR) | 1.6 | 4.9 | 0.4 | 0.9 |
| Simple Payback (Years) | 8.5 | 2.8 | 35.2 | 15.7 |

Based on the life cycle cost analysis, this ECO qualifies for both restrooms and breakrooms. However, only restrooms with three or more two-lamp fluorescent fixtures per circuit qualify with a payback less than ten years. No restrooms in the hospital meet this criteria. Therefore, only occupancy sensors in breakrooms are recommended.

**ECO #MI4 Install Natural Gas Desiccant Cooling**

**Description**

This ECO evaluates installing a desiccant cooling system for the third floor surgical suite area. The system will remove moisture from the air using a solid desiccant. The existing AHU provides the remaining sensible cooling. The desiccant is regenerated using hospital steam.

**Analysis**

Desiccant cooling can be effective for system with high latent loads, low humidity space requirements, or both. The surgical suite area (since it is a 100 percent outside air system) is a likely candidate. A vendor supplied analysis was adjusted for air flow, utility costs and equipment efficiencies for this evaluation.

**Results and Recommendations**

| | |
|---|---|
| Construction Costs | $176,900 |
| Annual Utility Savings (Increase) | |
| Electricity (MBtu/Year) | 833 |
| Natural Gas (MBtu/Year) | (2,804) |
| Annual Energy Cost Savings (Increase) | ($1,200) |
| Savings to Investment Ratio (SIR) | -0.2 |
| Simple Payback (Years) | N/A |

Based on the life cycle cost analysis, this project is not recommended.

**ECO #MI6 Real Time Pricing Electricity Rate**

**Description**

Electricity for Fort Gordon and the EAMC is purchased from the Georgia Power Company. the EAMC is on a separate meter and is billed independently of the remainder of Fort Gordon. The rate is a combination of PLL-2, Power and Light Large and SE-7, Supplemental Energy. The PLL rate is a declining block type with a marginal energy price of 2.2 to 3.4¢/kWh. The demand charge is $0.80/kW during the summer months (June through September). These rates are explained in detail in Section 3.2.

The SE rate requires that the hospital reduce its demand below 2,960 kW upon the request of the utility. This typically occurs 20 to 30 hours per year during the hottest summer days. During this time, the hospital energizes two generators, one 800 kW and the other 2,100 kW. The hospital has never failed to meet the curtailment requests during the eight years on this rate. However, as mentioned in Section 3.2, failing to meet the curtailment would cost the hospital about $92,000 over a year's time.

**Analysis**

There is an alternative rate that would remove this risk. It is called RTP-DA, Real Time Pricing - Day Ahead. This rate is available to any user for new capacity or capacity on either SE or IS (interruptible Service) rates. Another real time pricing rate, RTP-HA, Real Time Pricing - Hour Ahead is available only to customers with demand greater than 10,000 kW.

The RTP-DA rate would allow the hospital to generate or purchase the supplemental energy (i.e., energy above 2,960 kW) at prices presented one day in advance. The decision is up to EAMC and there is no penalty for failing to generate. Georgia Power Company has done an analysis that indicates that if the hospital operates its generators about the same number of hours per year it current does, hospital electricity costs will not change appreciably.

There are several benefits to this rate. It removes the $92,000 risk the hospital currently has if it fails to reduce load upon request. The decision when to generate is controlled by the hospital. Finally, the hospital will receive credit for reducing demand below the 2,960 kW level at the quoted rate for that hour.

There are a few downsides to the RTP rate also. The hospital must contract the rate for five years and are committed to at least one. More significantly, the hospital would be penalized if its loads drop. Under the RTP rate, the hospital will pay a fixed amount each month on the PLL rate and receive credits or debits each hour the demand is under or over the Customer Base Load (CBL). The CBL can be determined by several methods.

It is based on the historical electricity loads and will vary throughout the year. Therefore, if the hospital loads decrease during hours of low RTP rates, the credit will not totally offset the PLL rate.

Currently, the marginal rate for electricity is 2.2¢/kWh for energy purchased on the PLL rate and 3.5¢/kWh for supplemental (>2,960 kW) energy. If the hospital loads drop below the CBL and the RTP prices are, for example 2.0¢/kWh, the hospital would pay 0.2¢/kWh for energy it did not use up to the CBL. The point is that the hospital would be penalized if its loads decrease in the future. However, if the reduction is due to energy efficient equipment, Georgia Power Company can adjust the CBL to accommodate equipment replacements.

**Recommendations**

Since the hospital and the heating and cooling plant are in the process of making substantial energy efficiency improvements, it would not be wise to pursue the RTP rate until later. At least one calendar year of operation with the improvements are needed to establish a new baseline.

## 4.2 MULTIPLE ECO PROJECT EVALUATIONS

### FEMP1 - Energy Saving Projects

The first FEMP project combines the following ECOs:

| | |
|---|---|
| EL6 | Convert to energy-efficient motors |
| HS13 | Use damper controls to shut off air to unoccupied areas |
| HS18 | Reduce heated or cooled outside air |
| HS24 | Surgical suite supply air reset |
| LT2 | Reduce lighting levels |
| LT4C1 | Retrofit compact fluorescents in restrooms |
| LT4C2 | Retrofit compact fluorescents in lobby downlights |
| MI3B | Install occupancy sensors to control lighting in breakrooms |

### Results

| | |
|---|---|
| Construction Costs | $177,200 |
| Annual Utility Savings (Increase) | |
| Electricity (MBtu/Year) | 5,600 |
| Natural Gas (MBtu/Year) | 3,521 |
| Annual Energy Cost Savings (Increase) | $52,200 |
| Savings to Investment Ratio (SIR) | 4.4 |
| Simple Payback (Years) | 3.2 |

## 4.3 OPERATION AND MAINTENANCE RECOMMENDATIONS

This section is divided into two parts. The first section covers those recommendations that should be covered by the 1996 Major Renovation Project. The second section, beginning on page 4-57, include those recommendations that are pertinent even after the Renovation Project is completed. A list of the items discussed are below.

**Affected by Renovation Project**

1. HVAC:
   a) Straighten AHU Cooling Coils and Repair Damper Linkages
   b) Correct Building Air Balance

2. Boilers:
   a) Repair Economizers
   b) Clean Boiler Tubes
   c) Repair Fuel-to-Air Ratio Controls
   d) Replace Missing Steam Line and Duct Insulation

3. Cooling Tower:
   a) Repair Float Valves

**Discussion:**

1. HVAC:
   a) Straighten AHU Cooling Coils and Repair Damper Linkages.
      - AHU-1,2 and 3: Replace the roll filter media; straighten/comb cooling coil fins where bent.
      - AHU-4E: Straighten/comb cooling coil fins where bent.
      - AHU-4W: Cooling coils should be cleaned. Straighten/comb cooling coil fins where bent. Repair relief air damper linkage where it is coming loose from the wall.

   b) Correct Building Air Balance. Readings at second, third and fourth floor entrances revealed that the facility's negatively pressurized with respect to the outside. Although the values were small (0.01 to 0.04 inches of water) this can cause air conditioning problems in building perimeter areas. RS&H recommends that during the FY96 Renovation Project that the building air systems are balanced to provide positive building pressurization.

2. Boilers:

a) Repair Economizers. If the economizers and ID fans are removed as scheduled, the gas side pressure drop caused by the economizer surface and compensated for by the ID fans will disappear. The FD fan inlet vanes will have to be recalibrated to provide the additional pressure drop necessary to move the required air through the unit.

b) Clean Boiler Tubes. The boiler tubes were reportedly visually inspected during boiler shut downs in 1995. They are reported to be free of scale and in good condition. The boiler water chemical reports and practices support this observation. The pH is very high and the residual $Ca^{+}$ is <1 ppm indicating a low scaling potential. There is no need to clean the internal surfaces of the boilers at this time. The boilers should be shut down once per year and internally inspected for tube scale, pitting, corrosion and general internal pressure part condition. If boiler water treatment is kept under control, scaling will not become a problem.

c) Repair Fuel-to-Air Ratio Controls. The $O_2$ instrumentation should be made functional again. It should be restored to accurately indicate in the control room the $O_2$ for each boiler. The operator should have this information available to allow him to make manual adjustments to the air/fuel ratio controls to maximize boiler efficiency. The table below lists $O_2$ stack concentrations for various excess air values for gas and oil. This is shown graphically for various stack gas temperatures in Figure 4.3-1.

| Excess Air (%) | Stack $O_2$ (%) |
|---|---|
| 10 | 2.0 |
| 15 | 2.8 |
| 20 | 3.5 |
| 25 | 4.2 |
| 30 | 4.8 |
| 35 | 5.5 |
| 40 | 6.0 |
| 45 | 6.6 |
| 50 | 7.2 |

Between half and full load, the boiler should be able to operate comfortably at ten to 15 percent excess air. Below 50 percent load the excess air should be increased as necessary to maintain safe furnace conditions. Safe furnace conditions below 50 percent load will have to be field determined using a combination of visual flame observations, stack $O_2$ measurements, burner air spinner vane adjustments and prudent operating practice.

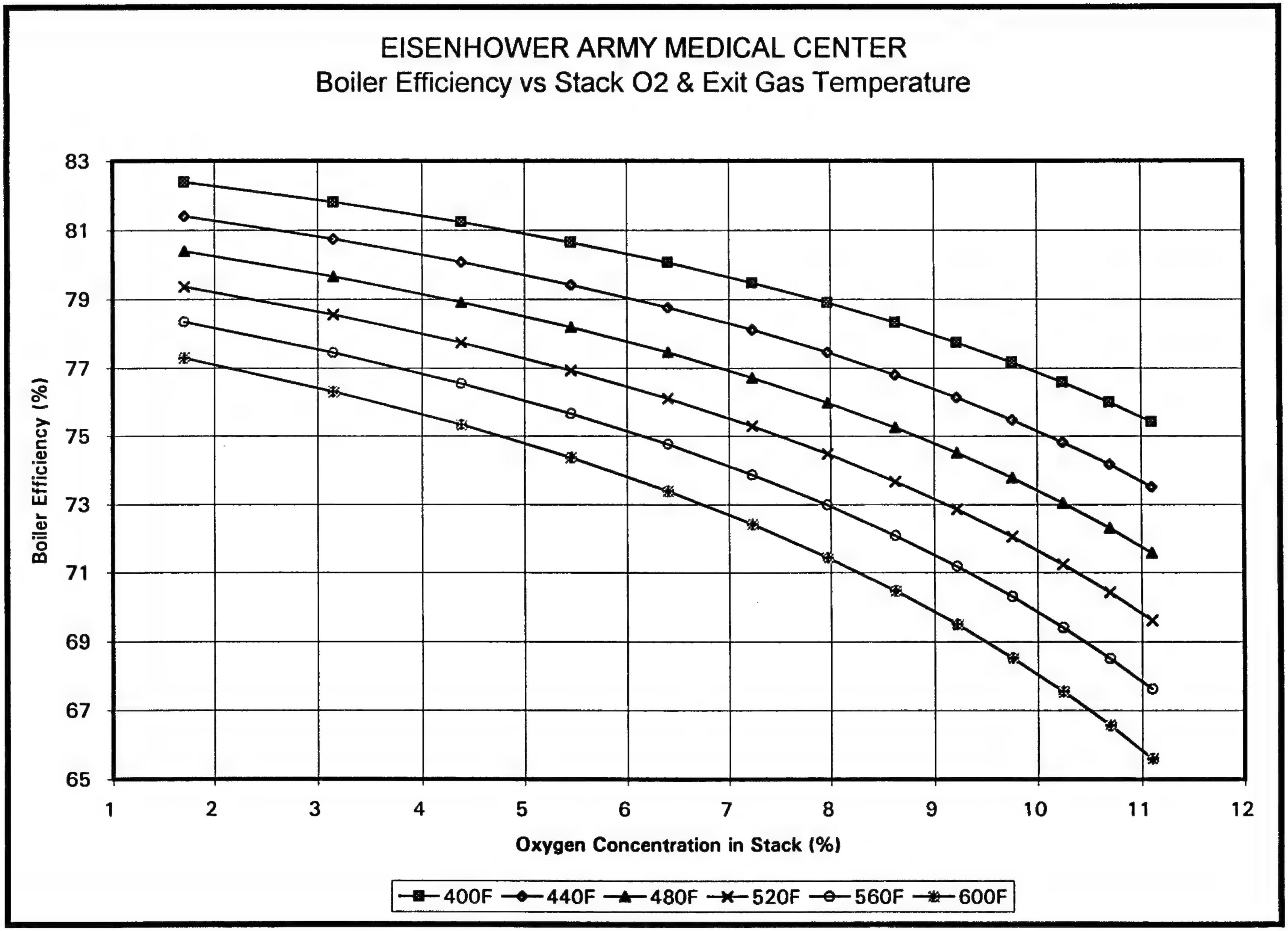

EISENHOWER ARMY MEDICAL CENTER
Boiler Efficiency vs Stack O2 & Exit Gas Temperature
83
81
79
77
75
73
71
69
67
65
Boiler Efficiency (%)
1
2
3
4
5
6
7
8
9
10
11
12
Oxygen Concentration in Stack (%)
400F
440F
480F
520F
560F
600F

**Figure 4.3-1**

d) Replace Missing Steam Line and Duct Insulation. DHW line, Second Floor Mechanical Room, ~30 feet Boiler Area.

| Line Size | | Length |
|---|---|---|
| 1" | 18' | Boiler Front Steam |
| 2" | 10' | Feedwater |
| 2" | 6' | BFP Discharge |
| 2-1/2" | 10' | Sootblower Line |
| 3" | 10' | BFP Suction |
| - | - | Steam Atomization Lines |

3. Cooling Tower:
   a) Repair Float Valves. CT#4 - Valve stuck open, wasting water. All remaining towers-either no float valve or not functioning correctly.

__Not Affected by Renovation Project__

1. HVAC:
   a) Clean Chilled Water Distribution Line Surfaces
   b) Clean Kitchen MAU Coil
   c) Reduce Overcooling Through Thermostat Adjustments

2. Boilers:
   a) Improve Fuel Oil Firing Operation
   b) Reduce Boiler Pressure to 60 psig
   c) Improve Feedwater Pump Operation
   d) Improve Boiler Water Chemistry
   e) Repair and Maintain Steam Lines and Traps
   f) Reduce Boiler Water Make-Up
   g) Renovate Hospital Low Pressure Regulating Valve Station
   h) Verify Steam Flow Chart Calibration
   I) Improve Atomizing Steam Problems

3. Lighting:
   a) Replace Exit Sign Incandescent Lamps on Failure
   b) Turn Off Lights When Not Needed
   c) Maintain Low Harmonics in Electronic-Ballasted Lighting Systems

4. Lightning Protection:

   a) Repair Deficiencies

**Discussion:**

1. HVAC:

   a) Clean Chilled Water Distribution Line Surfaces. Clean chilled water distribution lines within AHU-1, AHU-2, and AHU-3.

   b) Clean Kitchen MAU Coil. Heating coil should be cleaned. Replace the roll filter media.

   c) Reduce Overcooling Through Thermostat Adjustments. The following areas were overcooled during our survey.

| | Observed Values (degrees F) | Design Values (degrees F) | |
|---|---|---|---|
| | 10/24/96 | Summer | Winter |
| Elevator machine control room, Fourteenth Floor | 65 | - | 50 |
| Conference room 5B-40 | 73 | 78 | 68 |
| Linen, Third Floor | 72 | 78 | 68 |
| Hallways, Fifth Floor | 72 | 78 | 68 |
| Hallways, Twelfth Floor | 72 | 78 | 68 |
| Family Practice Room 16 | 72 | 78 | 68 |
| Family Practice Waiting Area | 73 | 78 | 68 |
| Computer Center (First Floor) | 67 | 70-74 | - |

2. Boilers:

   a) Improve Fuel Oil Firing Operation. It is important to remember when firing oil that atomizing steam pressure (boiler pressure) must be kept 15 psig above the oil required pressure <u>at the gun</u> to assure proper atomization of the fuel. This pressure varies almost linearly with boiler load (from ~ten psig to 120 psig at full load). Operating the boiler at 60 psig would limit the boiler output to 5,750 lbs/hr or 37 percent of its rated capacity.

   The operator has three options while operating on oil:

   - Use local electric-driven air compressors for atomizing air;

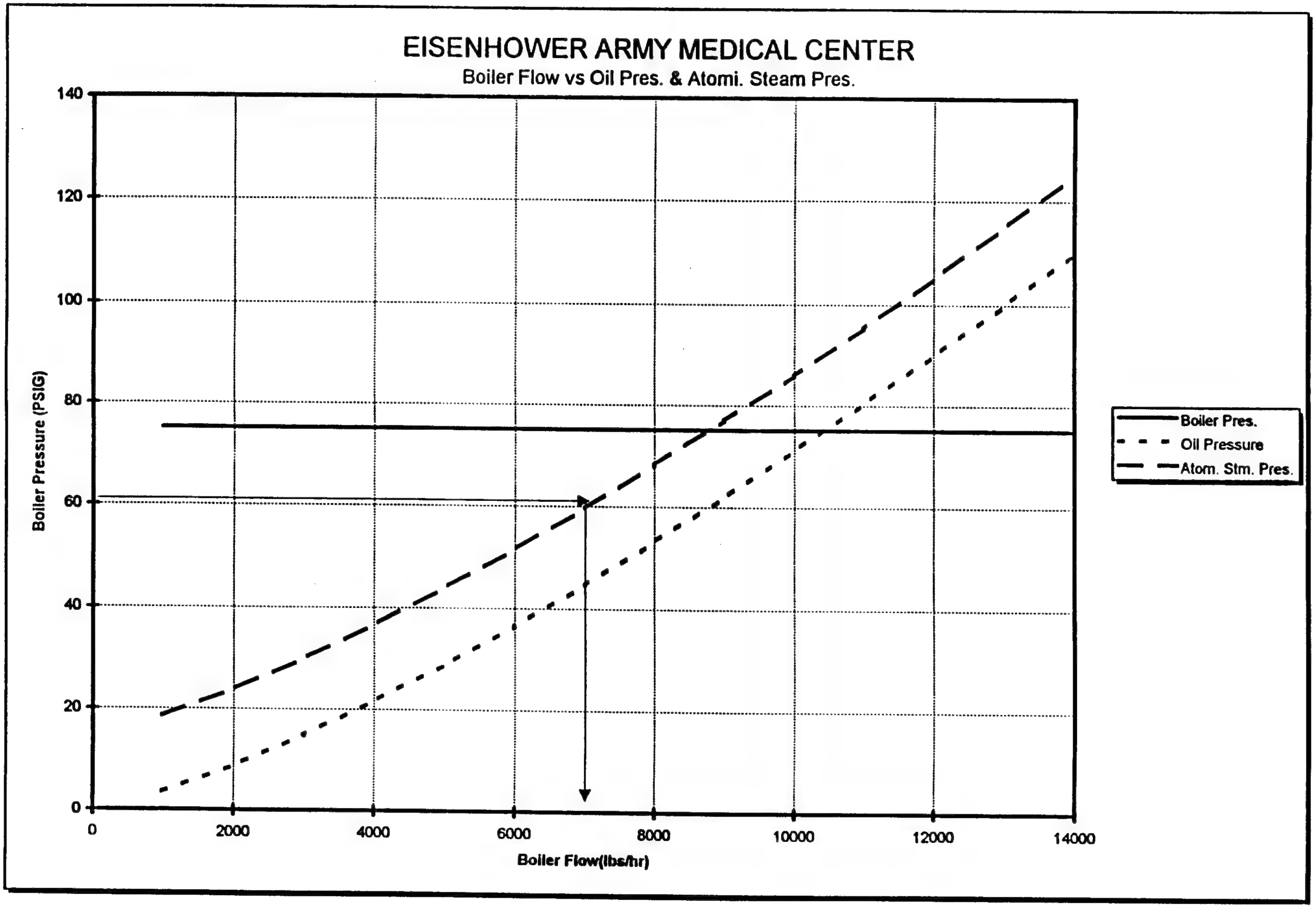
- Raise pressure on the boiler and system to 125 psig; or
- Put another boiler into service to satisfy the steam demand.

The boiler pressure will have to be raised to approximately 125 psig to provide the atomizing steam pressure required for full load operation on No. 2 oil using steam for fuel atomization. The oil gun tip pressure characteristic requires nearly full boiler pressure for proper fuel atomization at full load (see Figure 4.3-2). The operators should be made keenly aware of the relationship between oil gun pressure, atomizing steam pressure and boiler pressure. As the graph implies, at 75 psig boiler operating pressure, the maximum steam generating capacity is 8,500 to 9,000 pounds of steam per hour. If the operators increase the boiler load above 9,000 pounds per hour while operating at 75 psig there will be insufficient steam pressure to properly atomize the oil. Operating with a low atomizing steam pressure can be dangerous. Operating with atomizing air will not require that the boiler pressure be raised. However, if the atomizing air supply is interrupted, the atomizing steam pressure will be insufficient for full load operation. It would be wise, therefore, to use local electrical air compressors when operating on oil to assure sufficient atomizing steam pressure should the need arise.

The operators and instrument technicians should be provided with an operating manual that clearly shows or states how the coordinated control system controls the various boiler parameters. This manual should contain the design process set points as well as clear directions on how to adjust the controls to obtain these set points. This manual should be kept in the control room for ready reference. The existing conglomeration of manufacturer's manuals is incomplete and are virtually useless in the day to day operation of the boilers. The operators and instrument technicians are currently without any guidance beyond what their experience has taught them.

Currently, there are three air compressors in building 310. These compressors feed a common 100 psig receiver. All of the compressed air needs for the building are supplied from this receiver. Compressed air is used for "station" air, instrument air, and fuel oil atomizing air. The instrument air is dried before use with a small in-line dryer.

Operators report that the two Quincy air compressors, model 255, are out of service due to a broken discharge valve on one of them. Quincy reports this model air compressor is no longer manufactured. The Ingersol Rand compressor is supplying the compressed air needs of the building.



EISENHOWER ARMY MEDICAL CENTER
Boiler Flow vs Oil Pres. & Atomi. Steam Pres.
Boiler Pressure (PSIG)
140
120
100
80
60
40
20
0
0
2000
4000
6000
8000
10000
12000
14000
Boiler Flow(lbs/hr)
Boiler Pres.
Oil Pressure
Atom. Stm. Pres.


Figure 4.3-2

Peabody Engineering advises their oil gun consumes 4 $ft^3$ of compressed air per pound of oil atomized. At full load (15,400 lb/hr) for each boiler consumes 1,100 lb/hr of fuel oil. The compressed air consumption is therefore 4,400 $ft^3$/hr (73 cfm) at 125 psig. The existing Ingersol Rand (IR) compressor is rated at 100.7 $ft^3$/min. at 125 psig. Therefore the steam generating capacity of the building is limited to 21,150 lbs/hr while using compressed air for atomization. When the two Quincy compressors are repaired and restored to service, the maximum steam production using compressed air atomization will increase to 27,000 lbs/hr. Since the maximum boiler plant loads are about 24,000 lbs/hr, the existing compressed air system has adequate capacity.

Some operators have reported difficulties in changing from natural gas firing to No. 2 fuel oil firing when the weather is cold and the boiler load is high. The cause of the problem is water in the atomizing steam. Water in the atomizing steam causes flame instability of sufficient magnitude to cause the flame scanner to loose sight of the flame and trip the fires.

Water in the atomizing steam can be caused by, or aggravated by:

- Hospital steam surges
- Carryover of boiler water into the atomizing steam line due to unstable drum level control.
- Poor atomizing steam line trapping.
- Absence of atomizing steam line insulation

The solution to the problem is:

- Correct 35 psig pressure regulating valve surging.
- Stabilize the drum level
- Properly trap the atomizing steam line
- Insulate the atomizing steam line

A boiler consultant, Southern Energy Systems, Co. (SES) of Augusta, Georgia, was contacted about this problem. SES recommended the following:

- Reduce the sensitivity of the boiler master controller. This was done.
- Install new steam traps on the atomizing steam liner. This was done.
- Change the piping to allow condensate to properly drain to the traps in the atomizing steam line. This was done on #2 boiler by SES personnel to demonstrate. It will be necessary to disconnect three unions when required to enter the lower drum. Plant personnel should repipe the other two boilers in the same fashion.
- Install a proper feedwater distribution line in each boiler.

Oil was burned several times in May with no problems. However, the problems may reoccur under greater heating loads.

b) Reduce Boiler Pressure to 60 psig. The hospital autoclaves require a minimum of 50 and a maximum of 80 psig steam. This ECO evaluates the potential energy savings that result from reducing the boiler operating pressure to from the current 90 psig to 60 psig.

Combustion calculations were computed for 90 and 60 psig. The results indicated that as the pressure and exhaust gas temperature (EGT) were reduced the efficiency rose slightly, resulting in an energy and cost savings. The relationship between boil operating presence and efficiency is shown in Figure 4.3-3. The estimated savings are 464 MBtu/yr or $1,250/yr.

There is no capital cost associated with this ECO option. Savings will begin accruing as soon as the pressure is reduced. The operator can change the pressure set point from 90 psig to 60 psig on the plant master controller on the main control panel. When burning fuel oil, we recommend using atomizing air.

There are several problems that should be considered before reducing steam pressure at the hospital heating and cooling plant:

- Steam flow charts using orifice plates for flow measurement will read high
- Steam trap capacity will be reduced
- Oil atomizing pressure may be insufficient
- Feedwater pumps may cavitate
- Feedwater pump motors may overamp
- Feedwater control valves may cavitate

*Orifice Plate Steam Charts Read High.* Orifice plate steam charts read high because the density of the reduced pressure steam is lower than the design pressure. Reduced density means greater volume and, therefore, larger pressure drop through a fixed orifice for a given flow. This is illustrated in Figure 4.3-4. This can be permanently corrected by installing different orifice plates. However, until the decision is made to reduce the pressure to 60 psig, the readings can be adjusted by multiplying by a correction factor listed in the table below.

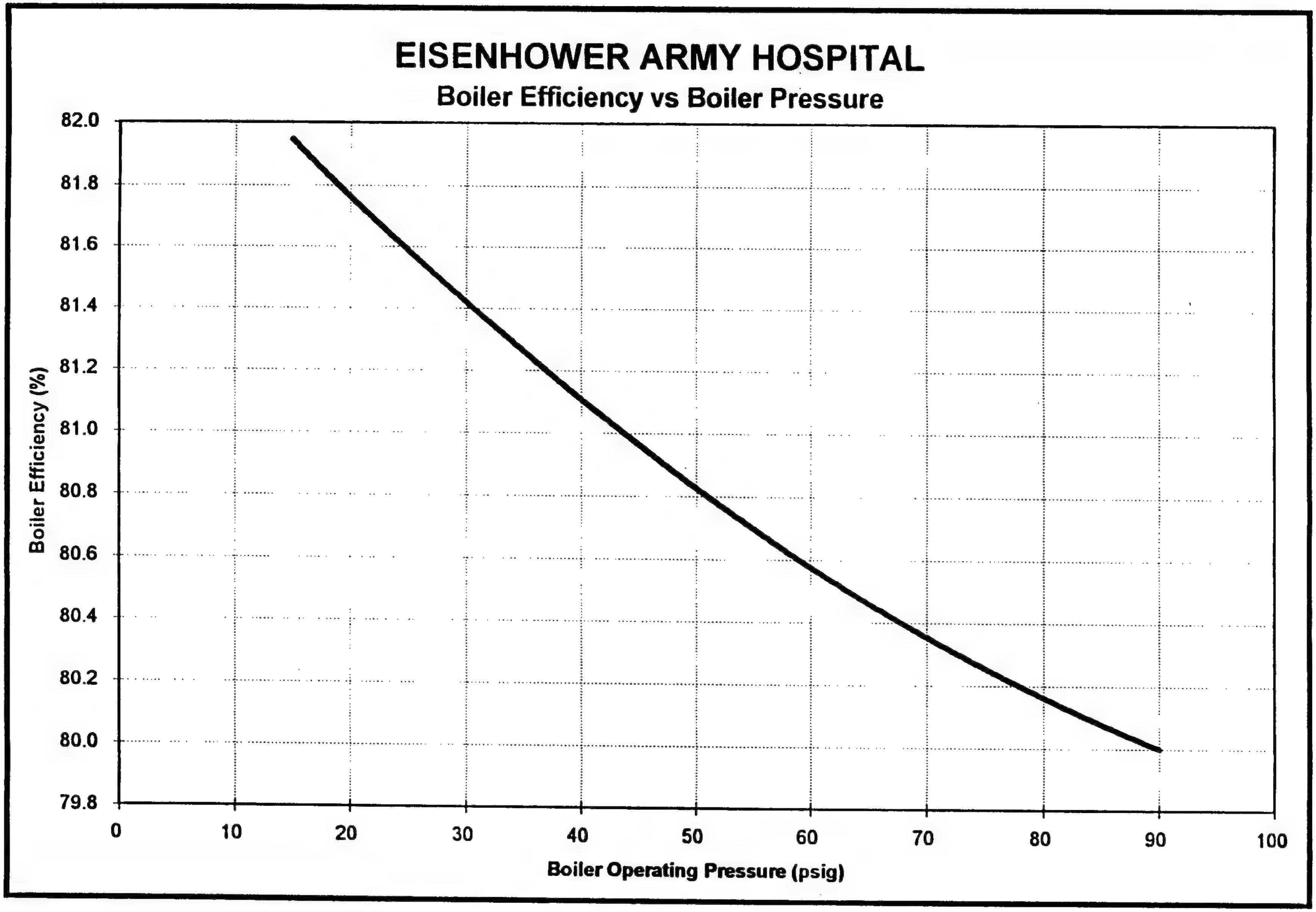

EISENHOWER ARMY HOSPITAL
Boiler Efficiency vs Boiler Pressure
Boiler Efficiency (%)
82.0
81.8
81.6
81.4
81.2
81.0
80.8
80.6
80.4
80.2
80.0
79.8
0
10
20
30
40
50
60
70
80
90
100
Boiler Operating Pressure (psig)

Figure 4.3-3

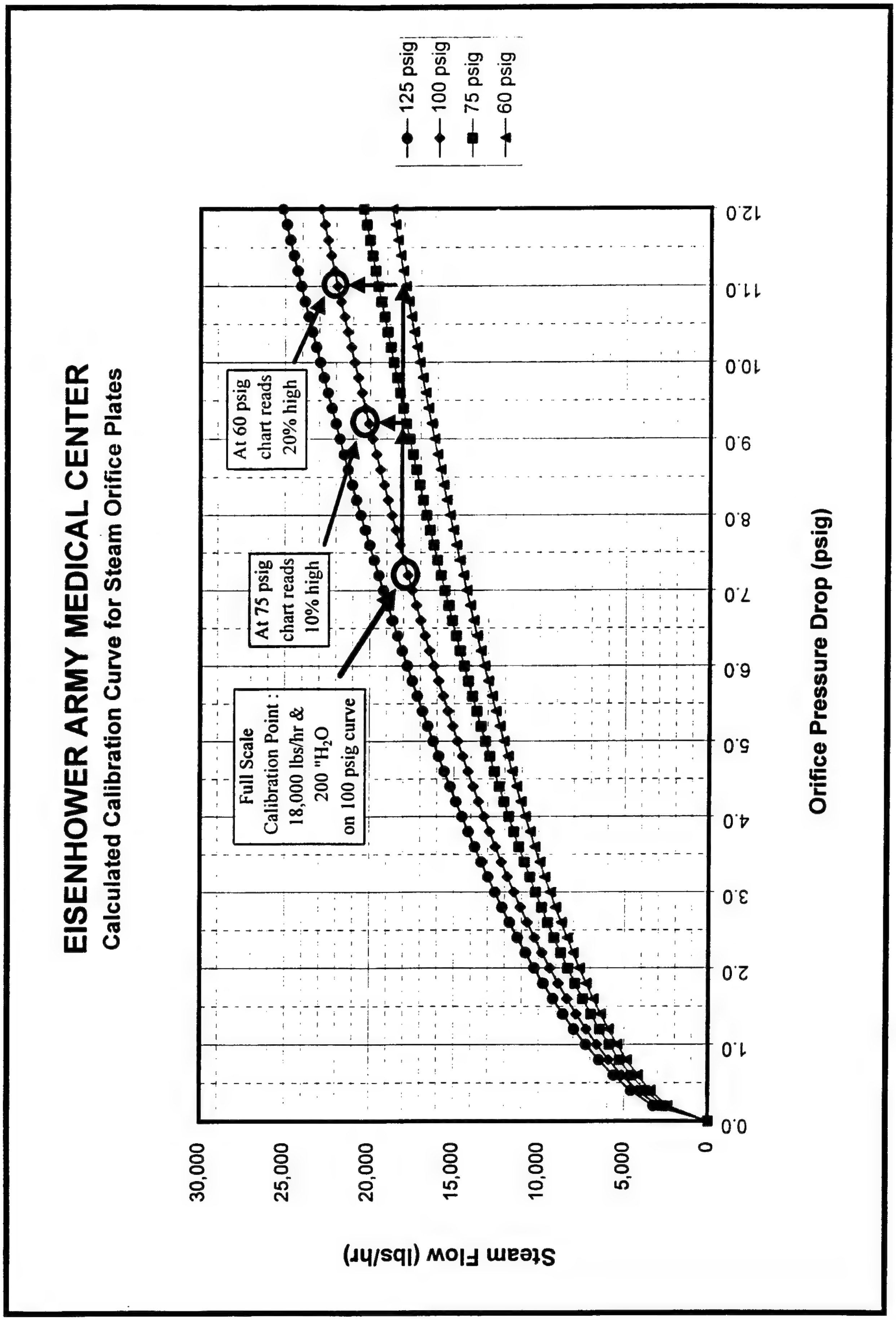

EISENHOWER ARMY MEDICAL CENTER
Calculated Calibration Curve for Steam Orifice Plates
Steam Flow (lbs/hr)
30,000
25,000
20,000
15,000
10,000
5,000
0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
Orifice Pressure Drop (psig)
125 psig
100 psig
75 psig
60 psig
Full Scale Calibration Point : 18,000 lbs/hr & 200 "H2O on 100 psig curve
At 75 psig chart reads 10% high
At 60 psig chart reads 20% high

Figure 4.3-4

**Orrifice Plate Steam Chart**

| Pressure Correction Factors | |
|---|---|
| Steam Pressure (psig) | Correction Factor |
| 100 | 1.0 |
| 75 | 0.9 |
| 60 | 0.8 |

*Steam Trap Capacity is Reduced.* Steam trap capacity is based on the amount of condensate that can be passed through the trap's orifice at a given differential pressure. Lowering the upstream pressure will reduce the differential pressure and could cause condensate backup and water hammer. Generally, this is not a problem since most traps are greatly oversized. This should be checked.

*Oil Atomization Pressure May Be Insufficient.* The effects of reduced steam pressures on oil atomization is discussed on page 4-58 "Improve Fuel Oil Firing Operation."

*Feedwater Pumps May Cavitate.* Decreasing the boiler pressure decreases the head pressure of the feedwater pumps, increasing the pump's flow capacity. This can cause problems if the pump is operating near its maximum capacity. As the flow increases with decreasing head, the required net positive suction head required (NPSHR) to prevent cavitation increases and the available suction head decreases due to increased friction losses.

*Feedwater Pump Motors May Overamp.* As flow increases with decreased head, it is likely that the motor will draw more current. Flow increases faster than head decreases as you move out on the pump curves. Also the pump efficiency likely decreases. All of these effects increase the motor hp requirements as shown in the equation below:

$$\text{bhp} = \frac{\text{gpm} * \text{head}}{3960 * \text{efficiency}}$$

The pump impellars can be trimmed to limit the pump's flow capacity and power draw. However, ASME code requires that the pumps are capable of supplying water to the boiler at a pressure three percent higher than the highest relief valve setting. Any changes in the

relief valve settings should be done by a certified instrument company according to ASME requirements.

*Feedwater Control Valves May Cavitate.* This can be a problem due to the combination of high temperature water and large pressure drops across the valve. The feedwater pump discharge conditions immediately upstream of the feedwater control valve are 155 psig and 250 degrees F. The vapor pressure of 250 degrees F water is 36 psig. At that pressure, it would flash to steam. The boiler pressure could not be operated below that pressure without modifying the feedwater pump to lower its operating pressure.

However, the pressures at the valve orifice will be even lower than the downstream valve. At the valve orifice, the velocities are the highest as the static pressure is converted to velocity pressure. Therefore, a safety factor should be applied. Depending on the valve, this value could be as high as 60 percent of the differential pressure. In this case, the maximum pressure drop across the valve would be (155 - 36) * 0.6 = 71 psig. This yields a minimum boiler operating pressure of 155 - 71 = 84 psig. To operate at 60 psig the feedwater pump discharge pressure would have to be reduced to 96 psig. For a boiler operating pressure of 75 psig, the pump discharge could be no higher than 135 psig. This problem may be alleviated by replacing the existing feedwater valves with one of higher resistance to cavitation under the reduced operating pressure conditions.

c) Improve Feedwater Pump Operation. The feedwater system consists of a deaerator and four full capacity pumps. Pumps 1 through 3 can be dedicated to their respective boilers, or, pump to a common feedwater header. Pump number 4 can pump to the header only.

Due to a combination of control problems and hospital steam demand surges, the operators have had difficulty controlling drum level. Occasionally, when the drum level is low and does not respond quickly enough to normal corrective action, the operators turn on an additional feedwater pump. It has been reported that in a few instances starting an additional feedwater pump has not raised the drum level as expected; while on other occasions, the drum level recovers so quickly that it overshoots. When the number of feedwater pumps is greater than the number of boilers in service the feedwater pressure can be much too high. To keep the pressure from getting too high a pressure regulator has been installed in a recirculation line around the number 4 feedwater pump.

The aforementioned regulator should be removed since it is not needed. Operators should continue their current procedures for bringing on line feedwater pumps as the load increases.

The problems with drum level control are caused by the 35 psig pressure regulating valve surges, coupled with the single element (feedwater valve controlled by drum water level only) drum level control loop, and a feedwater valve equipped with what appears to be quick opening internals. Additionally, the control system appears to be tuned to open and close the feedwater valve rather than modulate it. Ideally, with the boiler at half load and the drum level on set point the feedwater valve should be about half open- not shut off, and not wide open.

To regain drum level control the following action should be taken:

- Correct 35 psig pressure regulating valve surging.
- Make sure the feedwater control system is designed for "modulation" not "on/off" control.
- Check the design of the existing feedwater control valve. If existing valve does not have "equal percentage" internals, replace valve with same.
- If drum level instability persists, change the control loop to a two element control loop which would include steam flow as a variable.

d) Improve Boiler Water Chemistry. The boiler water chemistry and testing procedures need some attention. Boiler water pH tests are currently being conducted with litmus paper that does not indicate above eight. The operators are lulled into believing the pH is about eight because that is what the test procedure tells them it is. Actually, the pH could be anywhere between eight and 14. Independent data shows it is about 12.

The quarterly boiler water analysis conducted by an independent off-site lab consistently indicates the pH is in the range of 12, which is well above the recommended range of eight to 9.5. High pH levels can cause foaming and carryover. The operators have reported occasional carryover problems during heavy steam demands and large load swings. However, they are quick to assure that the carryover is not from foaming; although it is unclear how this conviction was reached.

In spite of having operated with high pH for a number of years, visual inspection of the boiler internals indicate no adverse effects. The tubes were reported to be scale free during a boiler inspection in mid 1995.

Additionally, the lab reports sulfite residuals are too low. The addition of Sodium Sulfite keeps dissolved $O_2$ to a minimum protecting the ferrous parts from corrosion.

Boiler total solids is very low indicating that the boiler blowdown is too high. The operators report that they blow down for only ten seconds. A ten second blow would require ten seconds to open the valve, ten seconds to blow and ten seconds to close the valve or 30 seconds total valve open time. This is about as fast as it can be done and still blowdown effectively. The only other option to reduce blowdown is to decrease the frequency of blowdown.

Specific recipes should be developed in concert with the new boiler water treatment company to bring the boiler water chemistry under control. These recipes and procedures should be rigorously followed. Boiler and downstream piping life depend on it.

The boiler plant should purchase a pH meter and stop using litmus paper. The recommended pH range for a boiler operating at this pressure is 8.0-9.5. The recommended sulfite residuals in the boiler water should be 30-50 ppm with 40 ppm preferred. The sulfite addition should be adjusted to hold 40 ppm.

The boiler blowdown frequency should be reduced. The boilers should be blown down only on odd numbered days for ten seconds (ten to open, ten to blow and ten to close). This will reduce the blow down frequency by approximately one half. The current blow down frequency is generating a 1,700 ppm total solids concentration. Halving the frequency will approximately double the total solids in the boiler water to the desired level of 3,000 to 3,500 ppm.

Water samples were taken at the DHW heat exchangers, the space reheat heat exchangers, city water, and raw steam to determine if the heat exchangers were leaking. The analysis showed no evidence of steam contaminating DHW or space heating water. The water sample analysis, others, and a summary tabulation can be found in the appendix, Operation and Maintenance section, Improve Boiler Water Chemistry.

e) Repair and Maintain Steam Lines and Traps. With the exception of one major steam leak on a main steam line flange of Boiler #3, the steam lines and traps were generally in good condition. No obvious waste was observed in either the hospital or the steam plant. The condensate storage tank temperature during a January visit was 150 degrees F indicating that quantity of steam bypassing traps was very low.

f) Reduce Boiler Water Make-Up. The only hospital steam consumers that do not return condensate are the autoclaves and humidifying air handlers. It is not practical to recover

these losses. Additional water losses in the boiler plant and distribution system from the boiler blowdown, sootblowing (soon to be eliminated) and general steam and water leaks could be saved. Current unaccountable losses cost the hospital about $5,600 per year.

The steam supply and condensate return serving the medical barracks were inspected and found to be in good condition. The mechanical rooms were dry and no condensate leaks were found. No obvious steam or condensate leaks were observed in the hospital.

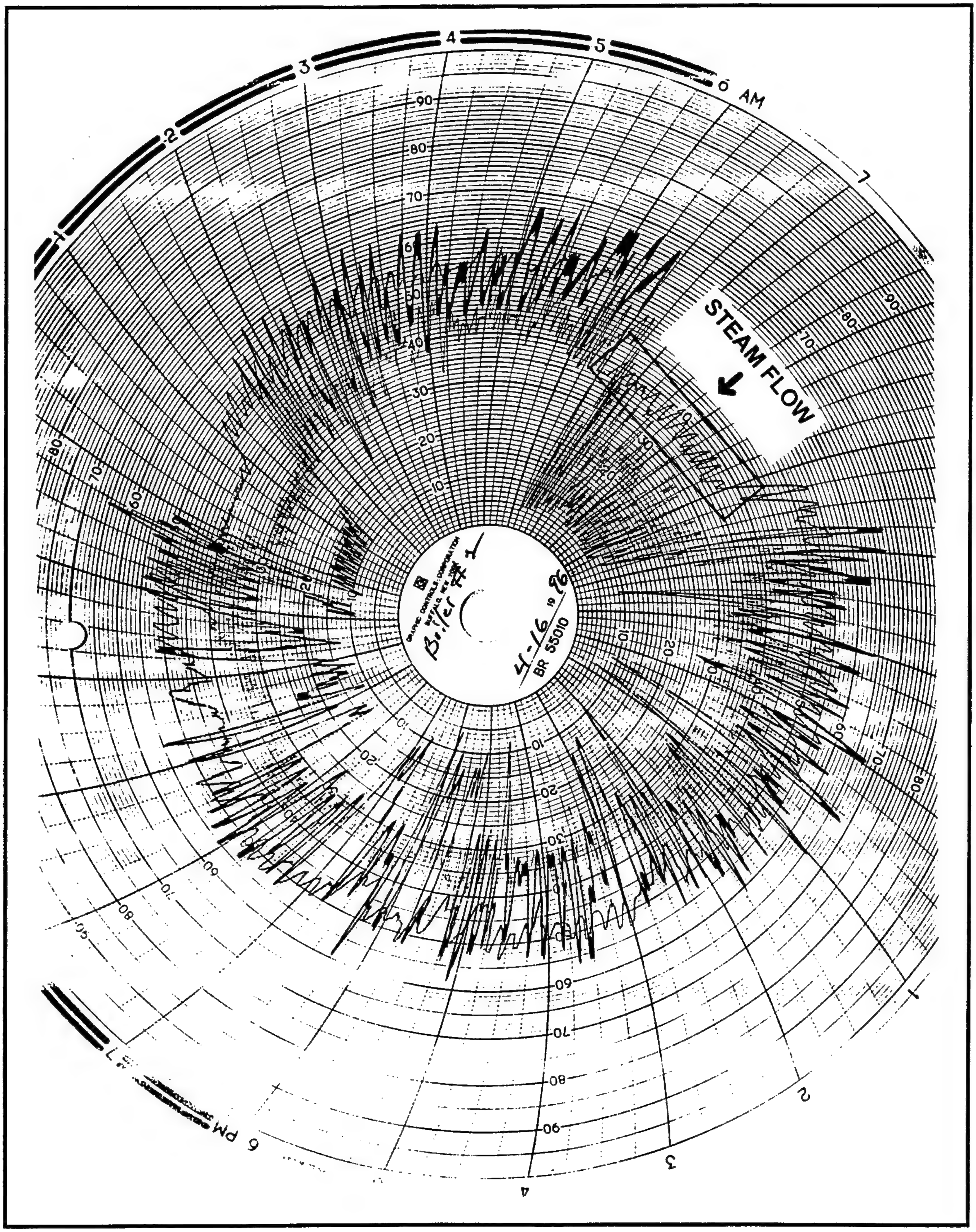
Uncovering the source of the system leaks is a time-consuming and continual process. Although we could not find any major leaks during our survey, perseverance and additional metering will help.

The boiler blowdown frequency should be decreased from daily. The boilers should be blown down on odd numbered days only. Operators and mechanics should be reminded to fix and report all steam and condensate leaks.

g) Renovate Hospital Low Steam Pressure Regulating Valve Station. The boiler steam flow chart recorders show extreme swings in steam production. This was noted in past surveys (p. 2-18). Survey trips in the fall of 1995 indicated cycling as much as 6000 lbs/hr, four to six times per hour. In June of 1996 the swings were about 2000 lbs/hr, 90 times per hour. These swings are consistent, 24 hours per day, month after month. There are no hospitals loads that could cause this kind of cycling. In the spring of 1996, a new controller was installed to help stabilize the downstream pressure. This was successful, but it appears to have worsened the cycling problem. Based on review of the boiler steam flow charts, this happened on or about April 17, 1996. Figure 4.3-5 is a copy of Boiler #2 chart for April 16, 1996. Note the typical steam flow cycling highlighted by the rectangular box. The flow is cycling about 1000 lbs/hr, six times per hour. The steam flow chart for the same boiler is shown in Figure 4.3-6 on April 18, 1996. The cycling increased 3600 lbs/hr and almost two cylcles per minute.

Another survey trip and test was conducted on August 13, 1996 to verify that the cycling was due to the controls and not hospital loads. The sensitivity of the controller was decreased and the effects observed. The steam flow chart for that day is shown in Figure 4.3-7. The adjustments decreased the magnitude of the fluctuations to about 1500 lbs/hr with a frequency of six cycles per hour. This confirmed that the controls are a major contributor to the cycling problem. A review of the PRV piping layout and controls revealed several problems.

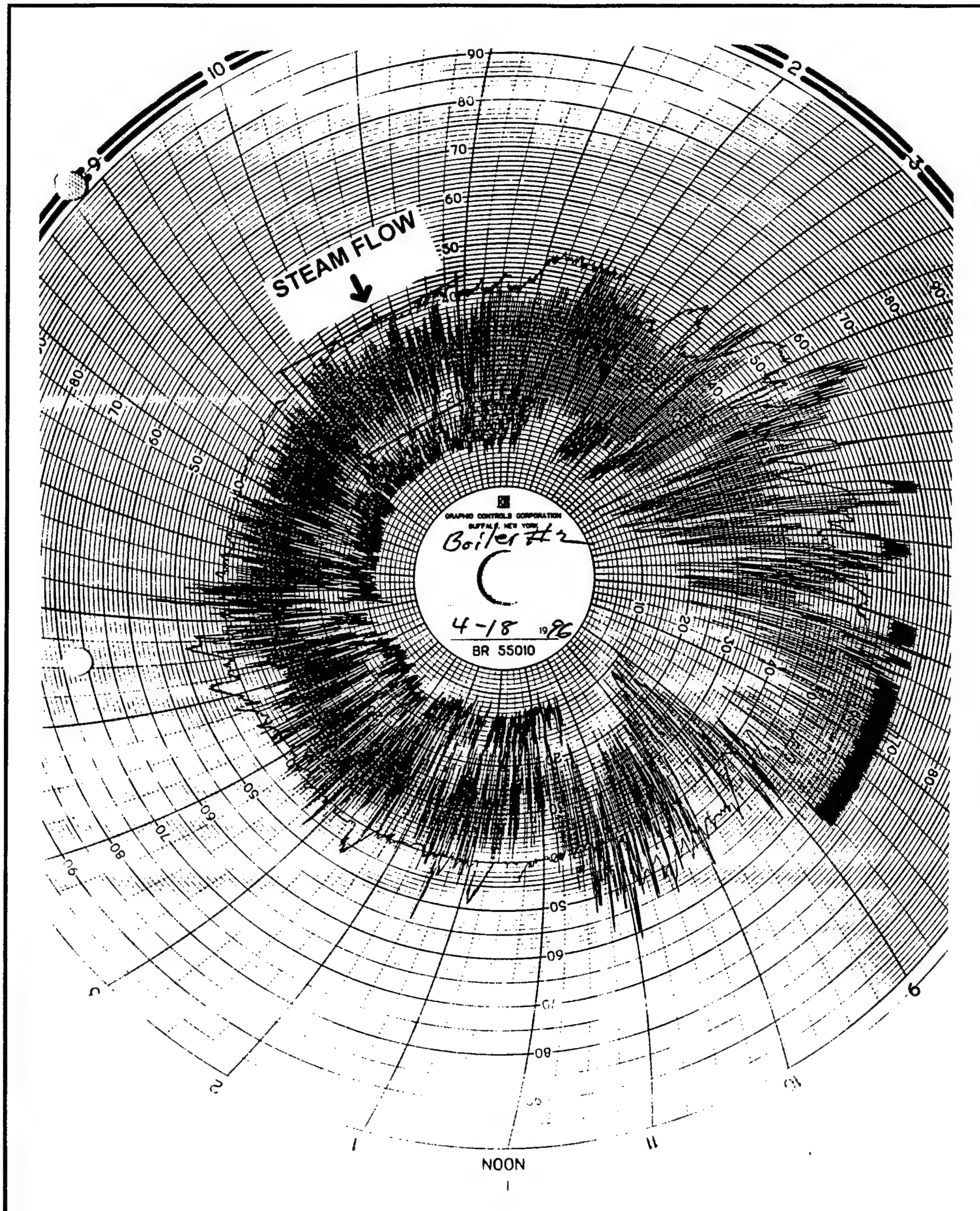
## Typical Steam Flow Noted Before 4-18-96




Full Scale = 18,000 lbs/hr.

**Figure 4.3-5**

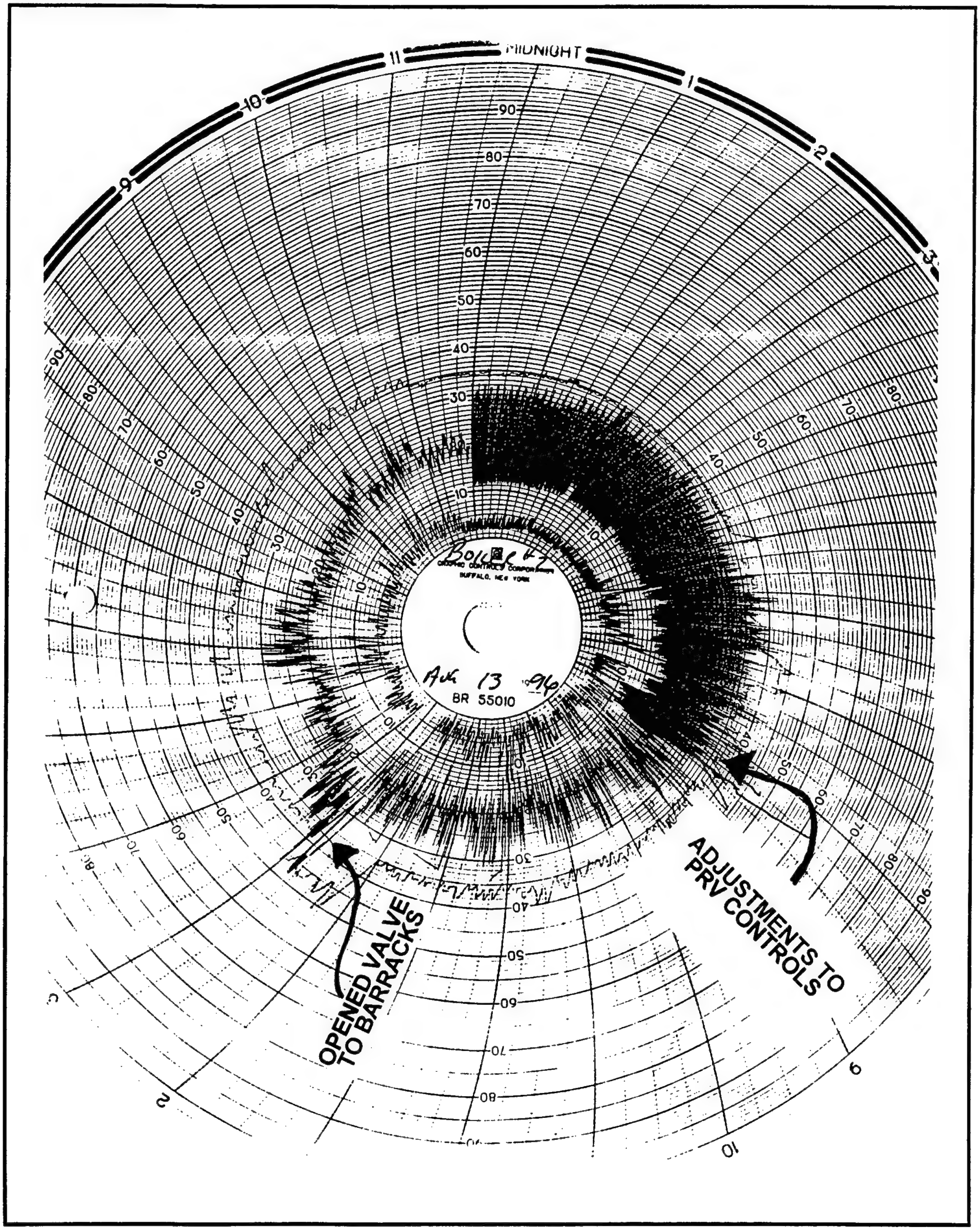
## Steam Flow Observed 4-18-96 to 8-13-96




Full Scale = 18,000 lbs/hr.

**Figure 4.3-6**

## Steam Flow During PRV Controls Adjustments




Full Scale = 18,000 lbs/hr.

**Figure 4.3-7**

- The PRV station is greatly oversized.
- The feedback control line is located improperly.
- The setpoint signal is not constant.

The following is a discussion of the existing systems, its problems and proposed design.

- High pressure (~100 psig) steam is reduced to low pressure (~32 psig) steam in the second floor mechanical room of the hospital. The system consists of two 6-inch Hoffman Air Pilot-Operated Pressure Regulating Valves, piped in parallel, rated at 40,000 lbs/hr each. Figure 4.3-8 shows a schematic of the existing PRV control system ( a more detailed diagram is contained in the appendix). There are several problems with this setup.

  First, the PRV capacity is excessive. Two 40,000 lb/hr valves in parallel yield a total capacity of 80,000 lbs/hr, which is over three times the largest steam demand ever observed (24,000 lbs/hr), and over two and one-half times the plant design capacity (30,000 lbs/hr, with 15,000 lbs/hr in a standby boiler). Hoffman warns that over sizing will cause "hunting" and premature wear.

  The feedback steam line is located after the main steam line begins to branch and is elevated about six feet above the PRV. Hoffman recommends this tap be located a minimum of 10 pipe diameters ( in this case five feet) down stream of the last point of turbulence and the line should be sloped <u>downward</u> going away from the valve.

  The source of the PRV setpoint is steam line pressure located just downstream from the PRV. This signal enters a transducer/controller where it is converted to an air pressure signal and sent to the PRV pilot. This system uses a varying setpoint, which is an inherently unstable design.

  The proposed design is shown in Figure 4.3-9. The feedback signal should be relocated immediately downstream of the PRV station, but at least five feet from the last point of turbulence. The line should slope downward going away from the valve. The old setpoint signal tap may meet these requirements.

  The pilot setpoint signal should be fed directly from a stable compressed air source through a controller that can provide a stable, <u>constant</u> air pressure.

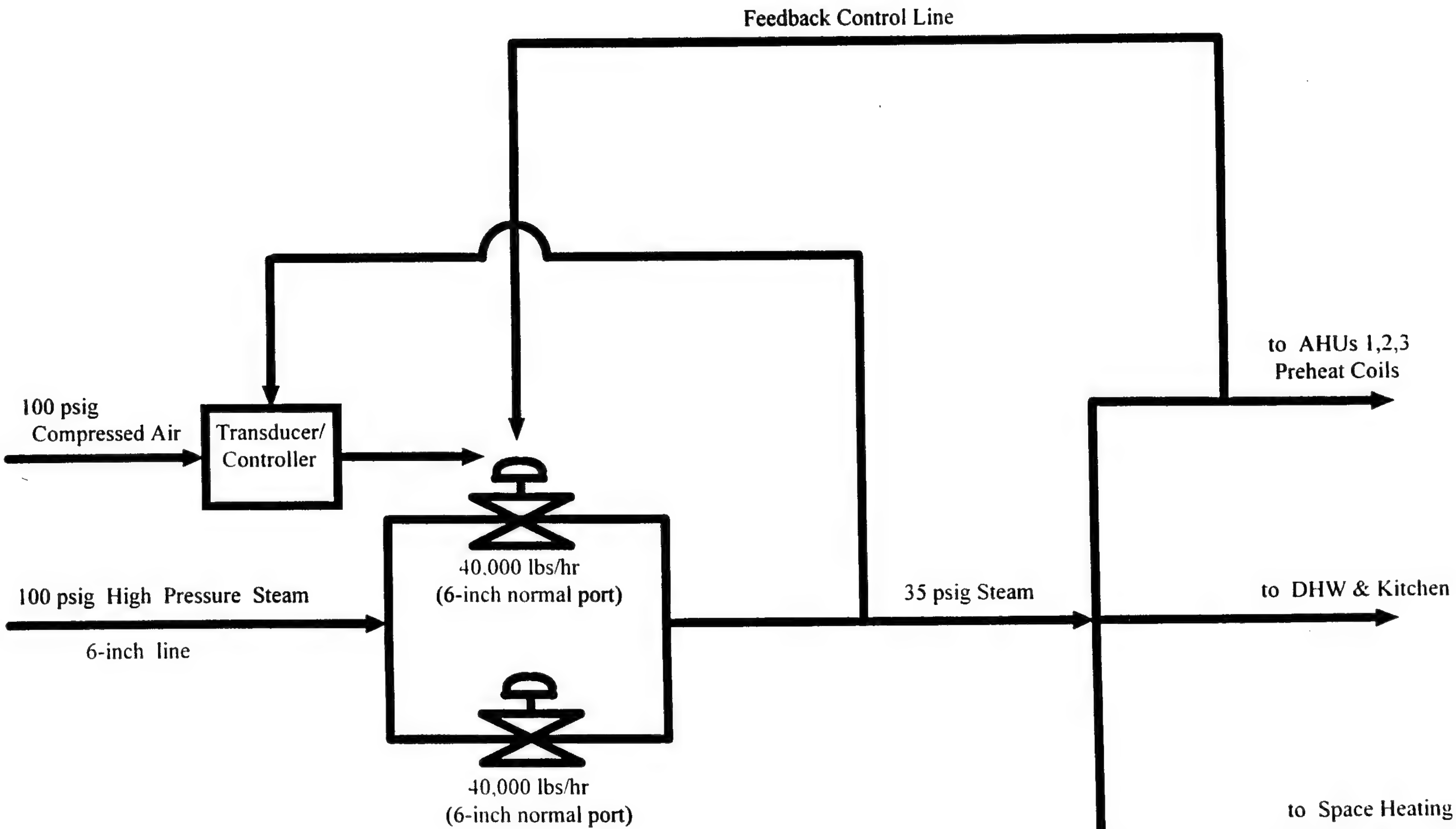



Figure 4.3-8 Hospital Low Pressure Steam Pressure Regulating Value Station - Current Configuration
( both valves are controlled with the same signals - only one is shown here)

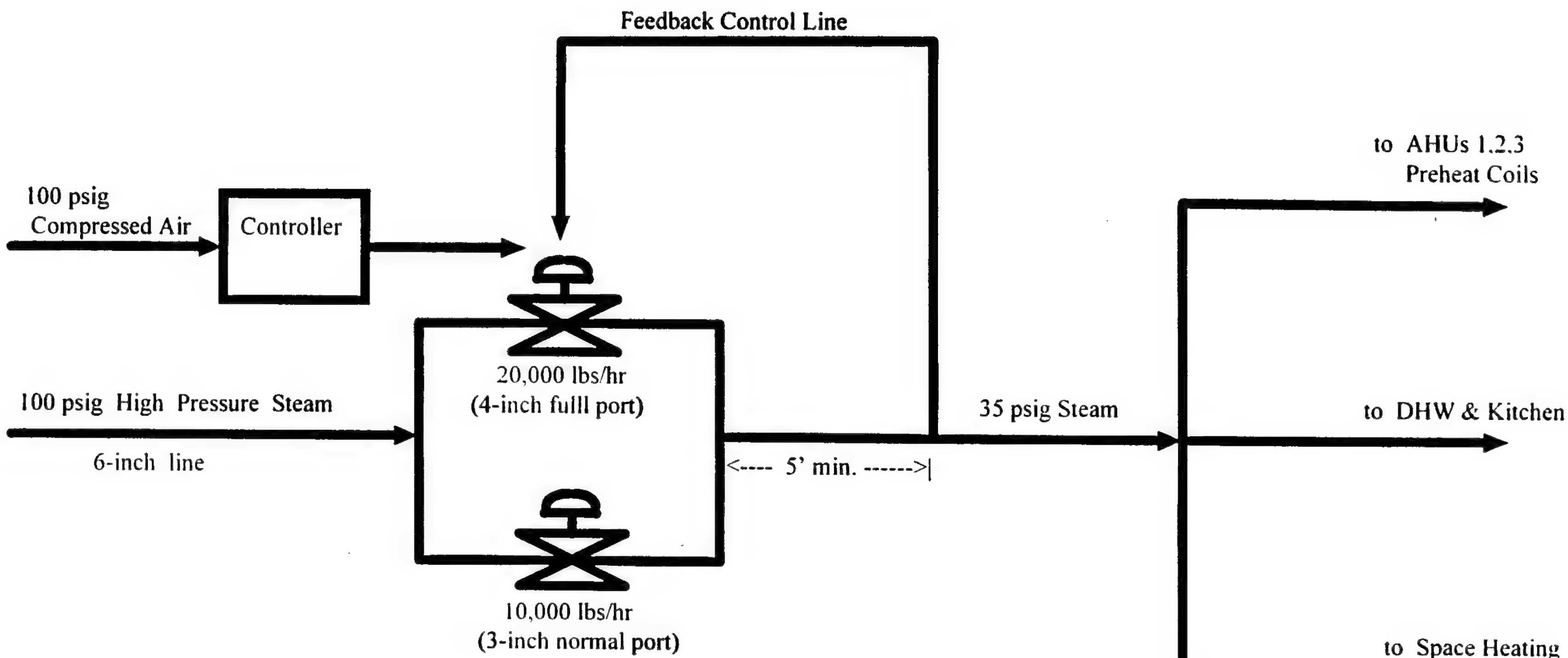



Figure 4.3-9 Hospital Low Pressure Steam Pressure Regulating Value Station - Proposed Configuration
( the smaller valve leads in a lead/lag operation)

The 10,000 lbs/hr valve controls would be set to open the valve before the larger valve. The small valve will be able to handle the loads until the outside temperature drops below about 40 degrees F (see Figure 2.2-4, p. 2-19). This occurs about 900 hours per year; therefore, the smaller valve will handle the load 90 percent of the year. The larger valve control setpoint should be slightly lower than the smaller valve. The larger valve will only open when the smaller valve cannot handle the load.

h) Verify Steam flow Chart Calibration. The following tests were performed on Boiler #2 on November 20, 1996:

- The current signal transmitted to the steam chart recorder was sampled while recording corresponding steam chart flow values and steam pressure. The transmitter produces a 4-20 milliamp signal corresponding to 0-200 $H_2 0$ pressure differential across the orifice plate. The current signal is proportional to the square root of the differential pressure. Therefore, the signal is linear with respect to steam flow.

Working from the transducer output the corresponding ▲P was calculated. These values were substituted into the equation for compressible fluid flow through orifices corresponding steam flow values were calculated. These data are compared to the steam chart readings in Figure 4.3-10. The steam chart readings matched the flows calculated using the transducer data within five percent.

I) Improve Atomizing Steam Problems. Water in the atomizing steam has been reported by the operators. The quantity of water in the atomizing steam has been high enough to occasionally extinguish the oil fires. The carryover problem allowing the water into the steam is being addressed elsewhere. However the atomizing steam piping should be designed to assure dry steam at the oil gun entrance.

An inspection of the atomizing steam piping on the boiler from revealed that the only trap was downstream of the atomizing steam pressure regulating valve, and is located in the same horizontal plane as the valve. First, the trap is located on the wrong side of the atomizing steam pressure regulating valve; it should be located on the upstream side of the valve. Removing the water from the steam before throttling will assure that all of the steam is superheated after throttling. Second, a one inch Tee is currently used to separate the water from the steam. The velocity of the atomizing steam is calculated to be approximately 80 feet per second. If the quantity of the water in the steam is sufficient to extinguish the oil fires, it

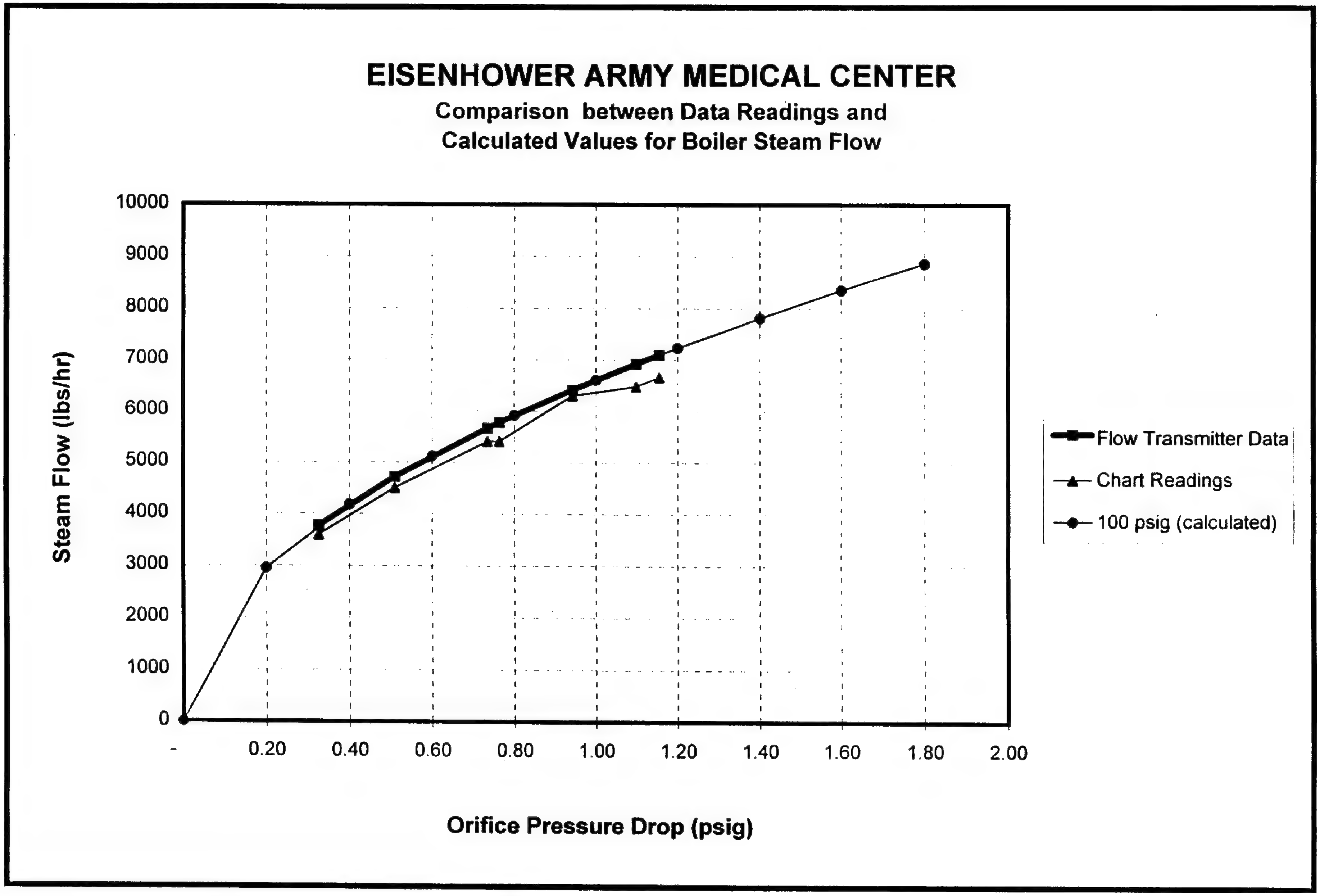

EISENHOWER ARMY MEDICAL CENTER
Comparison between Data Readings and
Calculated Values for Boiler Steam Flow
Steam Flow (lbs/hr)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
2.00
Orifice Pressure Drop (psig)
Flow Transmitter Data
Chart Readings
100 psig (calculated)

Figure 4.3-10

is not likely that the water can be separated from the steam within the short confines of the Tee. Finally, the trap should be located below the steam line so the heavier water can easily drop into it.

The enclosed sketch shows the existing piping and a recommended modification that will eliminate the problem. Briefly, a drop-out chamber should be located immediately upstream of the atomizing steam pressure regulating valve. The function of the drop-out chamber is to separate large quantities of water from the steam. A trap is still required in the water outlet line from the separation chamber. No trap is necessary downstream of the atomizing steam pressure regulating valve.

3. Lighting:

a) Replace Exit Sign Incandescent Lamps on Failure. Replace existing 24 watt exit sign lamps with low wattage LED type lamps in Family Practice wing. Retrofit kits cost about $25 each and are available from the Defense Supply Center, Richmond (1-800-DLA- BULB). New LED exit sign cost $60 to $100 and require one to two hours of labor to install. To minimize costs, these could be replaced on failure only.

b) Turn Off Lights When Not Needed. A nighttime survey of the hospital revealed that virtually all of the exterior room lights were turned off after dark. In general, the hospital staff appears to be conscientious about controlling lighting at the end of the work shifts.

The medical records area of the Family Practice wing is overlighted. Light levels were measured at 100 foot candles which is twice the recommended level. A wall switch de-energizes half the lamps in the fixtures. This should be used. Additional task lighting is available at each work station.

c) Maintain Low Harmonics in Electronic-Ballasted Lighting Systems. Harmonic currents are produced nonlinear loads such as electronic switching devices. Examples of these loads are computer power supplies, variable speed motor controllers and fluorescent fixtures lamp ballasts. When harmonic currents are present, odd triplen multiples (180 hertz, 540 hertz, etc.) of the 60 hertz fundamental frequency add together to result in a high amount of current on the neutral conductor.

For three-phase, four-wire systems, the neutral conductor carries the imbalances and harmonic currents for all three phases. This could result in currents on the neutral conductor

higher than on any one of the phases. Problems created by this are overheating of neutral conductors, bus bars and transformers.

The EAMC lighting system is predominately two-lamp fixtures utilizing T-12, F40 lamps and either standard or energy efficient magnetic ballasts. The hospital is in the process of converting most of the fluorescent fixtures to T-8 F32 lamps with electronic ballasts. The resulting fixture uses about 35 percent less energy than the original. However, concerns have been raised as to what affects the new lighting systems have on the harmonic distortion of the electrical system.

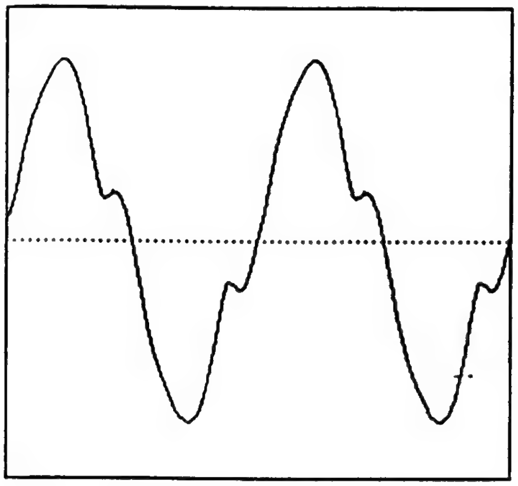
Current measurements were made comparing lighting circuit number two on the tenth and eleventh floors of the hospital. The tenth floor circuit has 25, two-lamp fluorescent fixtures. Three have T-12 F-40 lamps with magnetic ballasts; the remainder are T8s with electronic ballasts. The eleventh floor circuit has 30, two-lamp T-12, F40 lamps with magnetic ballasts. An Amprobe Harmonic/Power Analyzer HA-2000 was used to make the measurements of circuit currents.

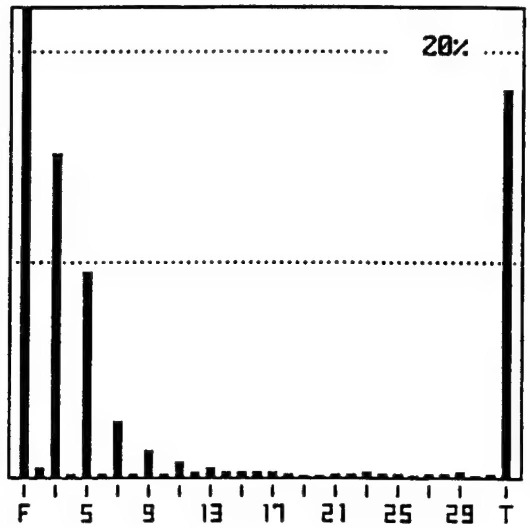
The results of the measurements are shown in the following figures. Figure 4.3-11 contains the measurements for the lighting circuit with the T-12 lamps and magnetic ballasts and Figure 4.3-12 the T-8s and electronic ballasts.

The magnetic ballast circuit has almost five times the harmonic current than the electronic ballast circuit. On a per-fixture basis, the ratio is four-to-one. The total harmonic distortion (THD) on the electronic ballast is 7.0 percent, compared to 18.1 percent for the magnetic type.

Most electronic ballasts can provide THDs less than 20 percent. This coupled with a substantial reduction in power requirement, ensures a net reduction in harmonic current when retrofitted magnetic with T-8, electronic ballast systems.

Some manufacturers market electronic ballasts that use an active filter to limit THD less than ten percent. These ballasts may cause high inrush currents that could damage contacts on switches, occupancy sensors or lighting contactors.

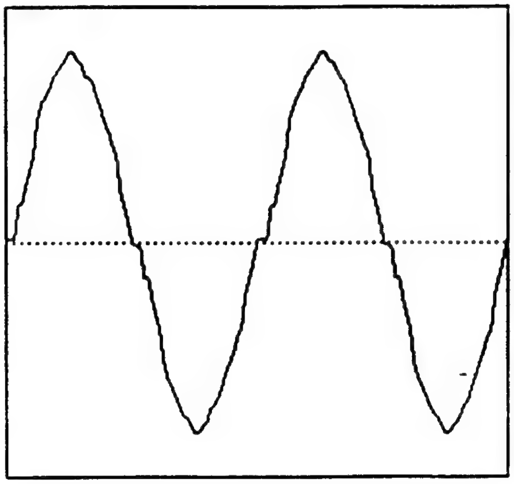


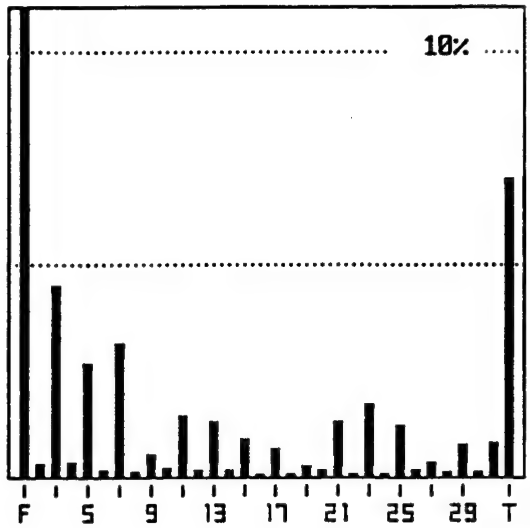



| CIRCUIT | | H | % | H | % | THD thru the 31st | |
|---|---|---|---|---|---|---|---|
| Total | 9.3 Amps rms | 3 | 15.1 | 19 | 0.0 | % THD | 18.1 |
| Fund | 9.1 Amps rms | 5 | 9.5 | 21 | 0.1 | | |
| Har | 1.7 Amps rms | 7 | 2.6 | 23 | 0.2 | % Odd | 18.1 |
| | | 9 | 1.2 | 25 | 0.1 | % Even | 0.6 |
| File: FTG03 | | 11 | 0.7 | 27 | 0.1 | % Triplen | 15.2 |
| | | 13 | 0.3 | 29 | 0.2 | | |
| Date: 01-26-96 | | 15 | 0.2 | 31 | 0.1 | K factor | 1.5 |
| | | 17 | 0.2 | | | | |

Amprobe Harmonalyzer

**Figure 4.3-11**
**Harmonic Curve Values - Magnetic Ballasts**






**CIRCUIT**

Total 5.11 Amps rms
Fund 5.10 Amps rms
Har 0.36 Amps rms

File: FTG01

Date: 01-26-96

| H | % | H | % |
|---|---|---|---|
| 3 | 4.5 | 19 | 0.2 |
| 5 | 2.6 | 21 | 1.3 |
| 7 | 3.1 | 23 | 1.7 |
| 9 | 0.5 | 25 | 1.2 |
| 11 | 1.4 | 27 | 0.3 |
| 13 | 1.3 | 29 | 0.7 |
| 15 | 0.9 | 31 | 0.8 |
| 17 | 0.6 | | |

**THD thru the 31st**

| | |
|---|---|
| % THD | 7.0 |
| % Odd | 7.0 |
| % Even | 0.6 |
| % Triplen | 4.8 |
| K factor | 1.6 |

Amprobe Harmonalyzer

## Figure 4.3-12
## Harmonic Curve Values - Electronic Ballasts

4. Lightning Protection:

a) Repair Deficiencies:

- Loose connections.
- Wrong type of terminations. Not enough surface contact.
- Conductor not secured.
- Copper conductor run along aluminum flashing.
- Metal drains and other metal object within six feet of main conductor not bonded.
- Kinks in conductor.
- Conductor longer than necessary.
- Conductor not bonded to metal conduit sleeve.
- Conductors not routed in downward direction.
- Connection to down conductors exceed maximum rise permitted.
- Highest piece of mechanical equipment or elevator machine room roof needs air terminal.
- Connectors designed for two cables have three cables.
- Air terminal missing.
- End of conductors extend beyond connector or bonding straps.
- Air terminal connected to main perimeter conductor with #4 solid wire.
- Flat copper strap wrapped around conductors without bolt for splice.
- Antenna base improperly bonded.
- Antenna cable laying on top of lightning conductors.

# 5.0 ENERGY PLAN

## 5.1 PROJECT PACKAGING

The ECOs in Table 4.1-5 were evaluated for their appropriate funding category. The scope of work lists the following guidelines for project funding.

- Federal Energy Management Program (FEMP)

  These projects are limited to $300,000 for construction and $1,000,000 for those classified as maintenance and repair. Any recommended project must have, as a minimum, a Savings-to-Investment Ratio (SIR) of 1.25 and a simple payback of 10 years or less.

- Energy Conservation Investment Program (ECIP) Projects

  These projects are for new construction or retrofit of an existing facility with costs greater than those listed above for FEMP. The project must have an SIR greater than 1.25 and a simple payback less than ten years.

Table 5.1-1 lists the ECOs that are recommended for funding. Although the total costs of all ECOs is greater than the $300,000 ECIP minimum, ECO #EL4 - Use Emergency Generator to Reduce Demand does not qualify for ECIP funds. This ECO has very little energy savings. Its savings come from a credit paid by the electric utility.

Table 5.1-1 Recommended ECOs - Ordered by SIR

| No. | ECO ID | Description | Construction Cost | Annual Savings Energy (MBtu/yr) Elec. | NGas | O&M | Annual Cost Savings | SIR | Simple Payback (yrs) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | HS24 | Surgical suite supply air reset | $1,400 | 738 | 1,984 | - | $11,000 | 108.0 | 0.1 |
| 2 | LT2 | Reduce lighting levels | $5,500 | 1,158 | - | - | $8,800 | 19.6 | 0.7 |
| 3 | HS18 | Reduce heated or cooled outside air | $1,100 | 136 | 32 | - | $1,100 | 12.7 | 1.1 |
| 4 | LT4C2 | Retrofit compact fluor's in lobby downlights. | $1,100 | 13 | - | $500 | $600 | 6.6 | 2.0 |
| 5 | MI3B | Install occ. sensors to control lighting-breakrooms. | $1,900 | 999 | - | - | $7,600 | 4.9 | 2.8 |
| 6 | LT4C1 | Retrofit compact fluor's in restrooms. | $37,500 | 231 | - | $8,500 | $10,300 | 3.3 | 4.0 |
| 7 | EL4 | Use emergency generator to reduce demand | $182,400 | 15 | (416) | $65,200 | $67,900 | 3.0 | 4.3 |
| 8 | HS13 | Use damper controls to shut off air to unoccupied-areas | $111,500 | 2,041 | 1,505 | - | $19,600 | 2.3 | 6.4 |
| 9 | EL6 | Convert to energy efficient motors | $17,200 | 284 | - | - | $2,200 | 1.5 | 8.9 |
| | Totals | | $359,600 | 5,615 | 3,105 | $74,200 | $129,100 | | |

* Fuel oil

## 5.2 ENERGY AND COST SAVINGS

Two FEMP projects were developed and are shown in Tables 5.2-1 and 5.2-2. Together, the two projects produce annual savings of 5,615 MBtu of electricity and 3,521 MBtu of natural gas. Fuel oil use is increased slightly (416 MBtu/yr). Annual O&M savings, which include demand cost reductions and utility credits, are $74,200 per year. Total annual savings are $129,100. The total savings are 5.9% in energy and 11.1% in energy costs.

When the FY96 Major Renovation Project is included, the annual savings are:

| Combined Project Savings (Includes FY96 Major Renovation Project | | | | |
|---|---|---|---|---|
| Fuel | Energy (MBTU) | % | Cost ($) | % |
| Natural Gas | 11,100 | 14.2 | $ 29,300 | 14.0 |
| Electricity | 13,700 | 16.5 | 229,700 | 21.2 |
| TOTAL | 24,800 | 15.4 | $259,000 | 20.0 |

The following ECOs were not recommended since the FY 96 Renovation Project was recently modified (in May 1996) to replace existing boilers with new ones.

- BP3 Increase boiler efficiency (repair controls)
- BP15 Install oxygen trim controls
- BP17 Install new unattended boilers

ECO #MI3A - Install Occupancy Sensors to Control Lighting in Restrooms - was removed also. The simple payback period was less than ten years only for restrooms that controlled at least three two-lamp fixtures with one switch. No restrooms meet this criterion.

ECO #LT4A1 - Retrofit Hallway Lighting with T8 Lamps and Electronic Ballasts - was also removed. The EAMC is currently involved in a project to accomplish this.

Table 5.2-1 FEMP #1 - Energy Saving Project

| No. | ECO ID | Description | Construction Cost | Annual Savings: Energy (MBtu/yr) Elec. | Annual Savings: Energy (MBtu/yr) NGas | Annual Savings: O&M | Annual Cost Savings | SIR | Simple Payback (yrs) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | HS24 | Surgical suite supply air reset | $1,400 | 738 | 1,984 | - | $11,000 | 108.0 | 0.1 |
| 2 | LT2 | Reduce lighting levels | $5,500 | 1,158 | - | - | $8,800 | 19.6 | 0.7 |
| 3 | HS18 | Reduce heated or cooled outside air | $1,100 | 136 | 32 | - | $1,100 | 12.7 | 1.1 |
| 4 | LT4C2 | Retrofit compact fluor's in lobby downlights. | $1,100 | 13 | - | $500 | $600 | 6.6 | 2.0 |
| 5 | MI3B | Install occ. sensors to control lighting-breakrooms. | $1,900 | 999 | - | - | $7,600 | 4.9 | 2.8 |
| 6 | LT4C1 | Retrofit compact fluor's in restrooms. | $37,500 | 231 | - | $8,500 | $10,300 | 3.3 | 4.0 |
| 7 | HS13 | Use damper controls to shut off air to unoccupied ar | $111,500 | 2,041 | 1,505 | - | $19,600 | 2.3 | 6.4 |
| 8 | EL6 | Convert to energy efficient motors | $17,200 | 284 | - | - | $2,200 | 1.5 | 8.9 |
| | Totals | | $177,200 | 5,600 | 3,521 | $9,000 | $61,200 | 4.4 | 3.2 |

Table 5.2-2 FEMP #2 - Emergency Generator Paralleling

| No. | ECO ID | Description | Construction Cost | Annual Savings: Energy (MBtu/yr) Elec. | Annual Savings: Energy (MBtu/yr) Fuel Oil | Annual Savings: O&M | Annual Cost Savings | SIR | Simple Payback (yrs) |
|---|---|---|---|---|---|---|---|---|---|
| 7 | EL4 | Use emergency generator to reduce demand | $182,400 | 15 | (416) | $65,200 | $67,900 | 3.0 | 4.3 |
| | Totals | | $182,400 | 15 | (416) | $65,200 | $67,900 | 3.0 | 4.3 |